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THE IMPACT OF THE U.S. ARMY'S ELIMINATION OF SUPPORT FOR THE M109A1-A4 ON THE CANADIAN ARMY: A STUDY IN ALTERNATIVE SOURCES OF SUPPLY

by

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This thesis examines the impact of the United States Army's elimination of support for the M109A1-A4 on the Canadian Army. The United States Army's Program Management Office for the M109 has determined support for the M109A1-A4 will be eliminated on 1 January 2000, including the Canadian Army's fleet of M109s. Prior to 1 January 2000, the Canadian Army must determine another source of repair parts for their M109 fleet. Two alternative sources of supply were analyzed and evaluated. They are: (1) Acquire repair parts through the NATO Maintenance and Supply Agency (NAMSA) and (2) Continue to use the remaining United States Army system and Canadian stocks and augment these stocks with other methods. The augmentation methods examined were the Simplified Nonstandard Acquisition Program (SNAP), Direct Commercial Sales (DCS), and Foreign Military Sales (FMS). Each of the two alternatives was analyzed based upon the needs of the Canadian Army and their capabilities. We conclude that the Canadian Army should continue to use their existing stockages of repair parts with augmentation from FMS if the repair part is still supported by the United States Army, and DCS if it is not.

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This thesis examines the impact of the United States Army's elimination of support for the M109A1-A4 on the Canadian Army. The United States Army's Program Management Office for the M109 has determined support for the M109A1-A4 will be eliminated on 1 January 2000, including the Canadian Army's fleet of M109s. Prior to 1 January 2000, the Canadian Army must determine another source of repair parts for their M109 fleet. Two alternative sources of supply were analyzed and evaluated. They are: (1) Acquire repair parts through the NATO Maintenance and Supply Agency (NAMSA) and (2) Continue to use the remaining United States Army system and Canadian stocks and augment these stocks with other methods. The augmentation methods examined were the Simplified Nonstandard Acquisition Program (SNAP), Direct Commercial Sales (DCS), and Foreign Military Sales (FMS). Each of the two alternatives was analyzed based upon the needs of the Canadian Army and their capabilities. We conclude that the Canadian Army should continue to use their existing stockages of repair parts with augmentation from FMS if the repair part is still supported by the United States Army, and DCS if it is not.

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I. INTRODUCTION

A. PURPOSE

On January 1, 2000, the United States Army will eliminate support for the M109A1-A5 Howitzers. This action will hinder the ability of numerous nations to acquire repair parts, and consequently, maintain the operational readiness of their M109 fleets. One of these nations is Canada. Their Army possesses 76 M109s in varying configurations from M109A2 to M109A4. (Equipment Logistics Directive (ELD) L-04-010-102/LM-001, 1997) By comparison, the current M109A6 version in the United States Army is significantly different. With the United States Army's support focusing on the M109A6, this difference is a critical factor. No longer will the Canadian Army be able to rely on the United States Army for a constant flow of much-needed repair parts. And their almost exclusive reliance on the FMS system exacerbates this issue.

When looking at the supply support management of the M109, there are two distinct areas, the turret (armament portion) and the chassis (vehicle portion). The armament portion is where the vast differences between the A4 and A6 models exist, and understandably, these are where the Canadian Army is most concerned. (Personal Interview with Major John Weaver, 1998) Included in this large number of hard-to-acquire repair parts and components are items such as the cannon assembly, traverse motors, hydraulic actuators and the complete recoil system. Making the resolution of this situation even more important is the fact that much of the technical data for these are strictly regulated by proprietary laws. As noted in the following research and analysis, this fact proves to be very important in obtaining and utilizing alternate sources of supply.

This thesis will provide research information on the United States Army's elimination of support for the M109A1-A4 model howitzers and its impact on the Canadian Army's ability to support their howitzer fleet. Additionally, the analysis will focus on the issue of what type of supply support system should the Canadian Army should use in the future. Based upon the analysis, the researcher will provide a recommended course of action for the Canadian Army.

B. BACKGROUND

The Canadian Army has been a Foreign Military Sales (FMS) customer of the United States since World War II. (North American Defense Industrial Base Organization Secretariat, 1987, p. 58) The relationship between the neighboring countries is very close. In fact they are the "world's largest trading partners, and the Department of Defense buys more goods and services from Canada than any other single foreign customer does." (North American Defense Industrial Base Organization Secretariat, 1987, p. 52) Given this close relationship, the Canadian Army's alternatives to obtaining support through commercial means are expanded.

In 1987, the United States and Canada signed a charter to establish the North American Defense Industrial Base (NADIB). Its purpose is to foster cooperative planning and defense industrial base development. A fallout of this agreement is the fact that there are many Canadian firms registered as planned producers in the United States' industrial preparedness planning (IPP) program. These are not specifically related to the production of M109 repair parts, but they will serve to augment the capability of the United States' producers of critical items during a national emergency. Additionally, the Canadian procurement policy has favored the purchase of United States' weapon

systems. Over 50 percent of all Canadian defense related purchases come from United States' firms.

All of this demonstrates that Canada does have some defense industrial capability. Additionally, there is a mutual dependence between the two countries and their on-going relationship has fostered an understanding of each other's system. Knowing all of this is important. It can have some impact on the Canadian Army's decision regarding a procurement strategy for M109 repair parts.

From 1994 to the present, the Canadian Army has experienced many changes. These are not unlike the changes in the United States Army. In fact, nearly all of them are a result of reduced funding and reduced public support for the Ministry of National Defense. Ministry of Defense (MND) is the term used to describe the entire defense organization for the Canadian Government, including the Army, Air Force, and Navy. It serves the same purposes as the Department of Defense in the United States Government. One of the most important changes in the MND is the complete restructuring of the Defense headquarters, including changing geographic locations. Embedded in this near transformation of the highest office in Canadian Forces is a shifting of the strategic vision and mission. As of the writing of this thesis, there is still a question as to the mission of the Army and the Canadian Forces. (Personal Interview, Major John Weaver, 1998) Many senior personnel argue that the mission of the Army is to support NATO missions and other rapid deployment operations. With this mission, there is no need for heavy artillery and tanks. (Personal Interview with Major John Weaver, 1998) Others still embody the need and desire to maintain a small armor and heavy artillery fleet in the event a larger conflict erupts. (Facsimile from Directorate of Artillery Systems Program

Management 3-2, 1997) (Personal Interview with Major John Weaver, 1998) Through all of this however, there has been one constant in the Canadian Army. It has continually supported NATO operations, and as discussed in the following chapters, this support has had a major impact on the fleet of M109s.

The history of the M109 in the Canadian Army is long lived. Their current fleet was purchased on two separate occasions in 1965 and 1985. (Equipment Logistics Directive (ELD) L-04-010-102/LM-001, 1997) The operational use of the M109s has not been extensive during their lifecycle in the Canadian Army. As stated previously, research indicated that many of the senior personnel in the Canadian Army feel the M109 is not an integral component of the Army's strategic mission. (Personal Interview with Major John Weaver, 1998) With its remaining operational life in question, the issue of support beyond January 1, 2000 for the M109 might be a mute point.

Further research, however, indicated the Canadian Army expended $50 million from 1993-1996 on the complete rebuild of the M109 fleet. (Personal Interview with Major John Weaver, 1998) This rebuild consumed a significant amount of Defense funding and is evidence that the Canadian Army is serious about maintaining the M109 in their operational plans. Consequently, it adds significance to maintaining the fleet's operational readiness.

Another program recently initiated on the M109 fleet is an extensive configuration verification exercise. (Personal Interview with Major John Weaver, 1998) It entails the physical disassembly of the two versions of the M109 and performing a comparison of all components to drawings. There are nearly 10,000 drawings on the M109. (Facsimile from Directorate of Artillery Systems Program Management 3-2, 1997)

(Personal Interview with Major John Weaver, 1998) Again, this is an expensive program that emphasizes the need to consider support for the M109 beyond 1 January 2000.

The low usage rates for the M109 fleet is a product of the Canadian Army's support to NATO operations. In this is further justification for analysis on future supply support for the M109. As this thesis is written, there are over 5,000 Canadian soldiers in Bosnia. (Facsimile from Directorate of Artillery Systems Program Management 3-2, 1997) (Personal Interview with Major John Weaver, 1998) These soldiers equate to a significant portion of the 25,000 in the total Army, and two-thirds of all artillery soldiers are included in this 5,000. (Facsimile from Directorate of Artillery Systems Program Management 3-2, 1997) (Personal Interview with Major John Weaver, 1998) If there are no soldiers, the equipment will not be operated. However, what happens when and if the NATO operations are decreased or eliminated? With a reduction in the OPTEMPO, it is likely that the usage rates of the M109 will increase as the soldiers and units conduct training and operational exercises in Canada.

C. SCOPE AND METHODOLOGY

The scope of this thesis is limited to analyzing the impact of eliminated support for the M109A1-A4 models on the Canadian Army. Included in this analysis is identification of alternative sources of supply and a determination of the optimum source.

The methodology used in this thesis research focused primarily on three methods interviews, quantitative research and analysis, and literature search. The interviews were conducted with the Canadian Directorate of Artillery Systems Program Management (DASPM) and the United States Army item managers at Rock Island Arsenal. The quantitative research and subsequent analysis was performed on the most important

repair parts for the Canadian Army's M109 support. A literature search was conducted on books, magazine articles, CD-ROM systems, the Internet and other library information resources. The literature search was performed throughout the thesis formulation. After all research was concluded, alternative sources for critical repair parts were identified and a comparative analysis was performed.

D. ORGANIZATION OF STUDY

Chapter I discusses an introduction to this thesis and provides pertinent background information for the thesis formulation.

Chapter II identifies key aspects of the Security Assistance program while applying them to the Canadian Army and the M109. It introduces the elements of Security Assistance and familiarizes the reader with the information necessary to understand its application to the analysis conducted in subsequent chapters. Direct Commercial sales is also introduced and discussed. Lastly, Chapter II provides an in-depth look at Cooperative Logistics Supply Support Agreements (CLSSA). As the primary means for the current supply support for the M109, the Canadian Army's CLSSA is thoroughly studied. Lastly, this chapter details the Simplified Non-standard Acquisition Process (SNAP) as a means for the Canadian Army to procure M109 repair parts.

Chapter III introduces a new source for M109 repair parts known as the NATO Maintenance and Supply Agency (NAMSA). With the NAMSA as a viable, alternative source, this chapter will outline all the aspects of joining the organization and lay the groundwork for the analysis and comparison in subsequent chapters.

Chapter IV is a comprehensive documentation of the Canadian Army M109 Program, including the political situation surrounding it usage. This chapter precedes the analysis of alternatives. Therefore, key information and underlying issues pertaining to the alternatives are identified and discussed.

Chapter V contains discussion and analysis on the identified, alternative sources of supply. The focus of this chapter is on analysis of each alternative and comparison between the alternatives. Simply stated, it looks at the advantages and disadvantages of each alternative source of supply and then compares the alternatives.

Chapter VI includes the conclusions and recommendation to the Canadian Army on the optimum source of supply for M109 repair parts beyond 1 January 2000.

E. RESEARCH QUESTIONS

1. Primary

- What is the impact of the United States Army's elimination of support for the M109A1-A4 models on the Canadian Army's ability to acquire repair parts for their fleet of M109A4 models?
- What is the best course of action for the Canadian Army to maintain an acceptable supply support system?

2. Secondary

- What are the components of Security Assistance?
- What is the nature of the Canadian Army's utilization of the Security Assistance program for M109 support?
- What is the Cooperative Logistics Supply Support Agreement (CLSSA)?
- What are the characteristics of the CLSSA with the Canadian Army?
- What is the Eurolog (NAMSA) organization and how is supply support obtained?

- What are the differences between the M109A4 and M109A5 models and what parts will not be supported (become obsolete)?
- What are the expected failure rates for the obsolete repair parts?
- What are the M109A4 usage rates and its expected lifecycle in the Canadian Army?
- How many of the obsolete repair parts are currently in the Canadian Army supply system?
- What are the alternative sources of supply available to the Canadian Army for the repair parts needed?

II. SECURITY ASSISTANCE

A. OVERVIEW

Security Assistance in its broadest sense describes the American military assistance to eligible foreign countries. Its purpose is to complement the United States' military strategy through enabling countries to defend themselves. Additionally, it is a means for promoting democracy and developing human and material resources for the defense of the free world. (Defense Institute of Security Assistance Management, 1997)

Security Assistance encompasses four key components that require funding from the United States Government (USG). Combined with these four are two additional components that require USG oversight and control. These are Foreign Military Sales/Foreign Military Construction and Direct Commercial Sales (Defense Institute of Security Assistance Management, 1997)

With these two included, there are a total of six (6) components within Security Assistance (Defense Institute of Security Assistance Management, 1997). All of these are addressed briefly below. Additional discussion of the components that are directly applicable to this thesis is located in subsequent sections. It is important to note that all foreign procurement of United States Defense equipment is executed through the implementation of one of these components.

1. Foreign Military Sales (FMS) Program and Foreign Military Construction Sales (FMCS) Program

Foreign Military Sales (FMS) as the name implies is the component of Security Assistance that allows eligible foreign countries to purchase military equipment from the United States. The key aspect of FMS is the Department of Defense must orchestrate the

purchase. (Defense Institute of Security Assistance Management, 1997, Chapter 3) FMS is a component that will be expanded upon in the following section. It is the primary tool for the Canadian Army to purchase repair parts and systems from the United States.

2. The Foreign Military Financing Program (FMFP)

Foreign Military Sales Financing is a component of Security Assistance that helps countries acquire military equipment even though they are fiscally constrained. This component has many of the same benefits of the previous components. Most notably is the strengthening of the military capabilities of the receiving nation. (Defense Institute of Security Assistance Management, 1997, Chapter 3)

3. Direct Commercial Sales (DCS) Licensed under the Arms Export Control Act (AECA)

Direct Commercial Sales (DCS) Licensed under the AECA is included as an element of security assistance for "Congressional oversight purposes." (Defense Institute of Security Assistance Management, 1997) In utilizing DCS, the foreign customer is purchasing United States military equipment directly from United States industry. This aspect is the difference between DCS and FMS. Another important aspect of DCS is that all sales are controlled through the Office of Defense Trade Control in the Department of States. These licensed sales are authorized under Section 38 of the AECA. (Defense Institute of Security Assistance Management, 1997)

4. The International Military Education and Training (IMET) Program

The International Military Education and Training Program (IMET) component focuses on the root of combat effectiveness, the soldiers' capabilities. Through training the soldiers of foreign nations, the United States is able to enhance the capabilities of the recipient nation. The additional benefit is being able to influence the doctrine of the

nation. Given the growing dependence on foreign partners, the need for a unified combat plan between nations is critical. IMET is a method for accomplishing this. (Defense Institute of Security Assistance Management, 1997)

5. The Economic Support Fund (ESF)

The ESF was established as a tool for the United States to promote political and economic stability in areas that contained special security and political interests. Additionally, it is applicable where the funding is deemed as a positive influence towards avoiding a potential conflict or economic crisis. The funding is awarded to recipient nations on a grant basis for a variety of economic purposes, "including balance of payments support, infrastructure, and other capital and technical assistance development projects." (Defense Institute of Security Assistance Management, 1997)

6. Peacekeeping Operations (PKO)

"Peacekeeping Operations (PKO) are authorized by Chapter 6 of Part II of the Foreign Assistance Act." (Defense Institute of Security Assistance Management, 1997) As the name implies, PKOs are a method for the United States to influence and aid foreign nations through active employment of personnel and equipment to maintain peace and stability. Listed below are the PKOs that were approved and funded for FY 97: (Defense Institute of Security Assistance Management, 1997)

- Multinational Force and Observers (MFO) -- $15.5 million.
- African Regional -- $2 million.
- Organization of African Unity (OAU) -- $3 million.
- African Crisis Response Force (PKO) -- $8 million.

- Organization for Security and Cooperation in Europe (OSCE) -- $18.6 million.
- Haiti -- $15.2 million.
- Israel-Lebanon Monitoring Group -- $1.2 million.
- Northern Iraq Peace Monitor Force -- $1.5 million.

B. APPLICATION OF SECURITY ASSISTANCE TO THE CANADIAN ARMY CASE

Not all of the security assistance components are applicable to the issue with the Canadian Army's M109 support. This portion of Chapter II focuses directly on those components of security assistance that are viable options for the Canadian Army. These are Foreign Military Sales (FMS) and its sub-component Cooperative Logistics Supply support Agreements (CLSSA) and Direct Commercial Sales (DCS). In the following sections, each of these will be discussed in detail and applied to the issue facing the Canadian Army.

1. Foreign Military Sales (FMS)

One of the most important assets for countries with a relatively small military force is FMS. It is important for many reasons, but the one that applies to this thesis is its enhancement of the repair parts procurement process. To illustrate the degree to which FMS is used by the Canadian Military, Table 1 provides the total Canadian FMS deliveries by fiscal year.

Table 1. Foreign Military Sales Deliveries

FY1993	FY1994	FY1995	FY1996	FY1950 to FY1996
$230,088	**$158,779**	**$127,795**	**$146,017**	**$3,567,232**

Source: Directorate for Information Operations and Reports (DIOR) (Dollars in Thousands)

By comparison to the United States Army, these Figures do not appear to be a considerable amount of money. However, to properly determine their significance, it is important to consider the military budget for the Ministry of Defense in Canada. During each of the fiscal years above, the annual budget for the Canadian Defense was approximately $7.5 billion per year. Comparing the two Figures, this equates to an average of 20 percent of the Defense budget being spent on FMS. (Facsimile from Directorate of Artillery Systems Program Management 3-2, 1997) (Personal Interview with Major John Weaver, 1998)

The degree to which the Canadian Defense relies on FMS is important. It demonstrates their dependence on the United States Department of Defense for supplies, repair parts and weapon systems. Ingrained in FMS are Cooperative Logistics Supply Support Agreements and the Simplified Nonstandard Acquisition Program (SNAP). Both of these are forms of FMS and will be discussed in Section II, B.4.

2. Direct Commercial Sales (DCS)

Another method for acquiring support for the M109 is through Direct Commercial Sales (DCS). Before discussing its application to this case and to facilitate better understanding by the reader, a brief comparison between FMS and DCS follows. This will better illustrate the actions involved with DCS and correlate these with its application to the Canadian Army case.

In the case of DCS, there is a contract between a United States Contractor and a foreign government. This contract is governed by United States laws and regulations, as well as applicable foreign and international laws and regulations. (Defense Institute of Security Assistance Management, 1997) Given the direct contract between the foreign

government and the United States contractor, there is not involvement of the United States Government. However, some governmental control is executed through the Office of Munitions Control of the Department of State. (Defense Institute of Security Assistance Management, 1997) The Department of State issues licenses that enable foreign countries to purchase the desired equipment/supplies from the United States contractor. (Defense Institute of Security Assistance Management, 1997)

By comparison, in the FMS system the contract for the equipment is between the United States Government and the contractor. (Defense Institute of Security Assistance Management, 1997) The USG is purchasing the items on behalf of the foreign customer. In this situation, the USG and the foreign customer enter into an agreement known as the FMS letter of offer and acceptance (LOA). (Karaahmet, 1994, p. 17) This document stipulates the terms and conditions of the sale. The USG then executes the contract with the contractor on behalf of the foreign customer. The entire contractual process is managed by the USG under the provisions of the Federal Acquisition Regulation (FAR). (Defense Institute of Security Assistance Management, 1997)

There are key questions to ask when a foreign country is attempting to determine which of these two methods to use in procuring materiel from the USG. These are highlighted in the following paragraphs:

One of the most important questions in any procurement is cost. How much will the equipment, including support, cost? The total cost must include the charges for all contractor costs and profits, including manufacture, delivery, training and support. The key difference in costs between the FMS and DCS is FMS costs are the final costs to the USG while the DCS costs are those normally agreed upon under the terms and conditions

of the contract. (Defense Institute of Security Assistance Management, 1997) (Karaahmet, 1994)

In some situations, the DCS might be faster or cheaper than FMS. Additionally, it is readily acknowledged and understood that the DCS process is simpler than FMS. However, the offset to all of these is the associated risk with each method. By using FMS as their procurement tool, the foreign customer eliminates nearly all of their risk for the purchase. In essence, the risk is shifted to the USG. The converse is true with DCS. The foreign customer assumes a significant portion of the risk in this case. The bottom line to answering the question of cost and distinguishing between the procurement methods is there are tradeoffs to consider. Even though one method might be cheaper and faster, the associated risks might necessitate utilizing the other procurement method.

A related question concerning the decision between FMS and DCS is what, if any, follow-on support is required. It is important for the foreign customer to consider this in their decision. The most significant reason for this is in a DCS situation, it is possible the foreign country purchased items slightly different than those in the USG system. In the event the customer wants to enter into a Cooperative Logistics Supply Support Arrangement (CLSSA) via FMS in the future, the support offered by this arrangement is likely to be hindered. The reasoning behind this is simple. If the equipment procured using DCS is different than the items in the USG inventory, the support offered by the CLSSA will be ineffective due to the difference in the components and sub-components. CLSSAs will be discussed in detail in Section II, B.3.

A third and final question regards the timeliness of the equipment delivery; how long will it take from the start of discussions to the delivery of the equipment? A direct

comparison of FMS and DCS demonstrates a key difference that can lead to longer times for the FMS. In the FMS procedures the total time involved includes time for the letter of offer and acceptance (LOA) negotiations, contract negotiations, production lead-time, delivery and training. (Department of the Army, Army Regulation 12-8 (Draft), 1994) The DCS quite simply includes all of this but the LOA negotiations. (Department of the Army, Army Regulation 12-8 (Draft), 1994) Therefore, it is possible for the DCS to take a shorter amount of time than FMS. Again, in making the decision, it is important to acknowledge the tradeoffs and risks involved with the decision.

In summary, there are many factors to consider when choosing between FMS and DCS. Unless the item is specifically offered as FMS, there are no absolutes in this decision. To the contrary, there are a significant number of considerations that are unique to the customer and the equipment being procured. "The final decision on purchasing channels varies from country to country, and even from purchase to purchase." (Department of the Army, Army Regulation 12-8 (Draft), 1994) Lastly, the purchasing government must consider as much factual evidence as possible prior to making a decision.

Direct Commercial Sales (DCS) is certainly a viable option for the Canadian Army. As described previously, there is a requirement for approval from the Office of Munitions Control of the Department of State. However, given the close relationship between the Canadian and United States' Governments, there is no reason for disapproval. Additionally, the Canadian Army has a long history of purchasing parts from United States manufacturers. The Canadian contracting system is quite familiar

the United States' system, making any purchase through DCS for the Canadian Army uneventful.

3. Cooperative Logistics Supply Support Agreements

a. Introduction

The FMS process is cumbersome, and by its nature, is not one associated with a speedy delivery. However, there has been a more recent program that allows a foreign country to literally become a customer of the United States Army supply system. This program, as an FMS case, is called the Cooperative Logistics Supply Support Agreement (CLSSA).

b. Description of CLSSA

This section examines, in detail, the process of CLSSAs and their significance to the foreign customer. They are considered to be one of the most effective means for replenishing in-country stocks of spares and repair parts. It is a program that is intended to be a method for supporting equipment purchased through the FMS system. It is considered to be the most responsive means for obtaining support. (Department of the Army, Army Regulation 12-8 (Draft), 1994)

As mentioned previously, the CLSSA is an FMS agreement where the United States furnishes repair parts and supplies (secondary items) to the purchasing country. These parts and supplies are provided in support of specific end items. The CLSSA agreement requires the country to provide some financial investment to the DoD logistics system. (Department of the Army, Army Regulation 12-8 (Draft), 1994) This financial investment is representative of the anticipated support requirements for the country's end items. The purchasing country identifies the items, which the country

anticipates using over a specific time period, normally 12 to 24 months. (Department of the Army, Army Regulation 12-8 (Draft), 1994, Chapter 9) This list is developed and is the basis for payment. With the financial investment made, the list also becomes the substantiation for the United States item managers to requisition additional stockages for support of the CLSSA. (Department of the Army, Army Regulation 12-8 (Draft), 1994, Chapter 9) The stockages purchased for the CLSSA customer are intermingled with the normal DoD supply system stocks. As the CLSSA customer requires parts and supplies, they are simply ordered from DoD utilizing the CLSSA channels. "Once an investment has been used to augment DoD stocks and a country desires to actually withdraw materiel for use in country, the country's payment for those items which it requisitions will provide funds which allow the United States to restore stock levels to support that particular country in the future under the arrangement." (Department of the Army, Army Regulation 12-8 (Draft), 1994, Chapter 9) As outlined, the process has a two step nature; one which establishes the countries CLSSA and one that requisitions the repair parts. Therefore, two FMS cases are required, Foreign Military Sales Order (FMSO) I and FMSO II. The FMSO I case is simply utilized to establish the CLSSA agreement and accept the country's investment to establish the DoD stocks. This FMSO remains in effect for the duration of the CLSSA, and no material is transferred to the customer. There is the possibility to adjust or renegotiate the FMSO when it is necessary.

There are two sub-components to the FMSO I: Part A, which represents the required quantity of stocks to be maintained on-hand by the United States, and Part B which represents a value of the stocks needed to maintain on-hand levels, based on the calculated lead-time for the items. "The Army bases the value of Part A of the FMSO I

on one-half of the reorder cycle value for each item. The value of Part B is based on the number of months of procurement lead-time plus one-half of the reorder cycle value." (Defense Institute of Security Assistance Management, 1997) The second case, FMSO II, is used to allow the country to requisition repair parts to replenish their in-country stocks as they are consumed. As mentioned previously, the payments under FMSO II cases are utilized for the replenishment of United States' stocks for supporting the CLSSA customer. (Defense Institute of Security Assistance Management, 1997)

c. The Canadian Army CLSSA

Having described the CLSSA and its significance to the foreign customer, it is now important to focus on the Canadian Army's CLSSA. The Canadian Army established numerous CLSSAs for their United States Military systems at varying dates. (Interview with Captain Gilles Vernier, 1998) Research indicated the M109 fleet has been supported with a CLSSA throughout its life cycle in the Canadian Army. (Interview with Captain Gilles Vernier, 1998) In other words, their military has been quite active in the use of the CLSSA as a means for its support. (Interview with Captain Gilles Vernier, 1998) (Interview with Captain Gilles Vernier, 1998) Total CLSSA expenditures for the Canadian Army in FY 98 (1 January 1998 – 17 November 1998) were $48,354,717, and the M109 fleet expenditure totaled $538,896. (Interview with Captain Gilles Vernier, 1998)

Reiterating information from Chapter I, the management of the M109 is segregated into two distinct areas the turret (armament portion) and the chassis (vehicle portion. The Canadian Army has operated the M109 fleet since 1968 and combined with the operation, they have developed in-depth knowledge of the complete system. This

knowledge combined with many unique operating environments has translated into desired changes in the M109 system. They have incorporated numerous changes in the chassis. (Personal Interview with Major John Weaver, 1998) The following Table illustrates these changes:

Table 2. Canadian Alterations to the M109 Chassis

Description	Parts/Components Affected
Winterization Kit	Hull, Engine, Hydraulics Reservoir,
Increased Engine Output	Engine, Heads, Turbocharger
Transmission 2nd Gear Steer and Shift Upgrade	Transmission
Improved Track and Road Wheel Rubber	Road Wheels and Track
Fire Suppression System	Engine Compartment Extinguishers and lines
Heater Upgrade	Cooling Lines on Engine and Crew compartment.

Source: DASPM 3-2.

These changes have led to a significant reduction to the dependence on the USG for support on the chassis. Additionally, it demonstrates where the CLSSA for the Canadian Army should focus, the cab (armament portion) of the M109. Combined with this information is the fact that historically, the components in the cab are the most difficult to obtain through any means other than the United States Army supply system. (Personal Interview with Major John Weaver, 1998) The reasoning behind this is the technical data for the components of the cab are proprietary and it is extremely costly to reverse engineer them. (Phone Interview with Mr. Jack Hyer, 1999)

The Canadian Army has used other means to support the M109. They have established an FMS case for the rebuild of the complete gun system with the

completion of this taking place in 1996. Additionally, they have established numerous FMS cases for the rebuild of various reparable items on the system, but the CLSSA is their primary means of support. And throughout the rebuild and other maintenance actions, supply support for the cab has been obtained from the United States Army. [(Interview with Captain Gilles Vernier, 1998)

4. Simplified Non-Standard Acquisition Process (SNAP)

There are additional FMS cases for which a CLSSA is not the best method for the country to obtain support. This is termed non-standard support. The use of non-standard items will have some impact on the follow-on support provided by DoD. "Non-standard items, as they relate to FMS, may be defined as any items or equipment not included in the DoD inventory or not purchased for regular use by DoD." (Defense Institute of Security Assistance Management, 1997) There are other items, which are considered non-standard. They include: the customer may change an item's design to improve the desired mission performance; the U.S. may change the design for security reasons; or, an obsolete item may be sold through property disposal channels or become obsolete as a result of technological advancements and improvements. (Defense Institute of Security Assistance Management, 1997) The nonstandard item special system applicable to this case is the Army's Simplified Nonstandard Acquisition Process (SNAP).

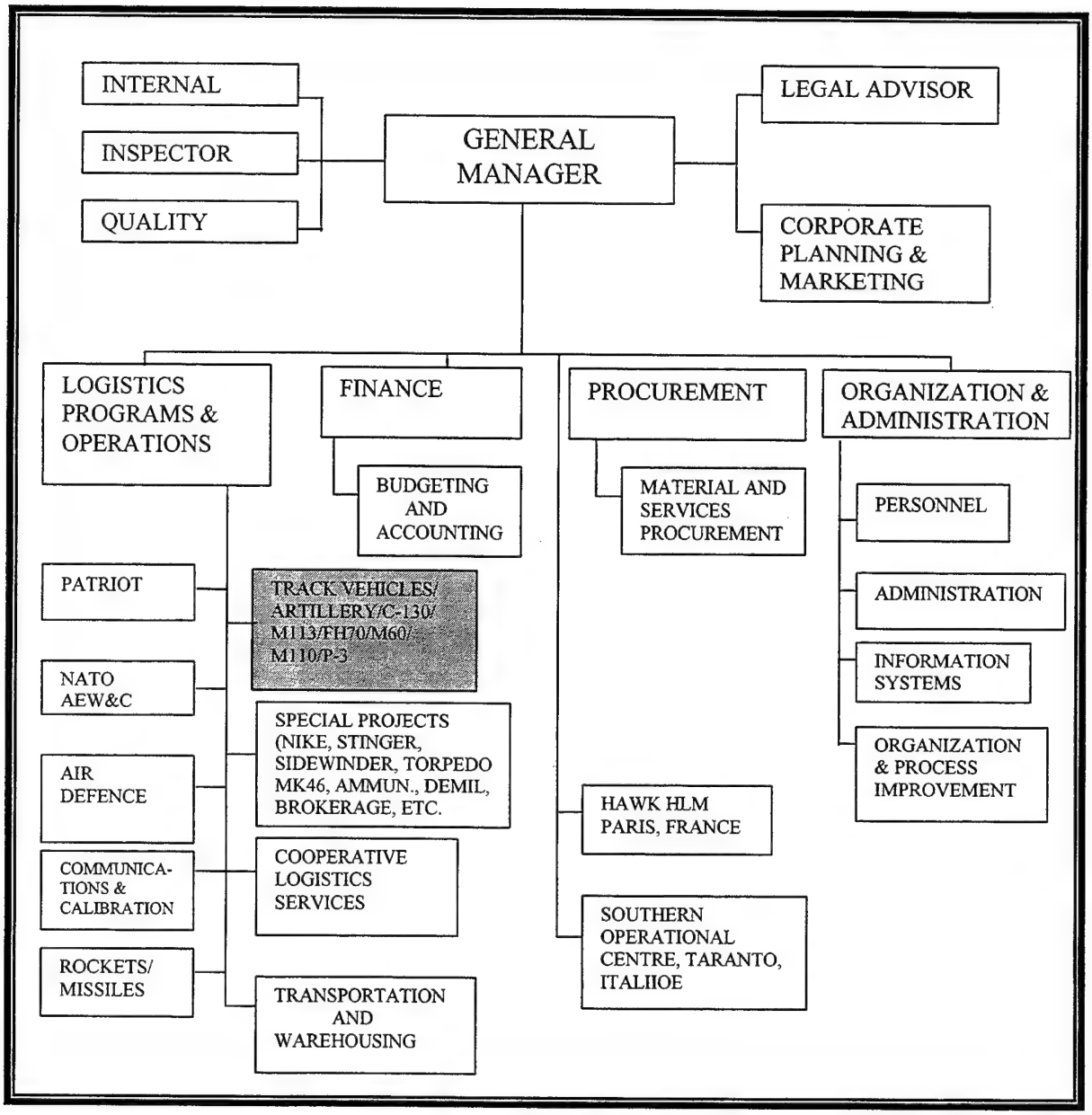
This system is used by the customer in the situations described above. The request is processed through DoD and then turned over to a contractor to research and obtain the required item. (Directorate for Information Operations and Reports, 1996) The item is provided to the Army, who will in turn, provide it to the customer country. (Directorate for Information Operations and Reports, 1996) The term simplified implies

it is an easy process for the foreign country to use because DoD performs the contracting. It is a simplified or "invisible" process to the foreign customer. However, research indicated that the SNAP acquisition takes a considerable amount of time. Discussions with Canadian personnel and Security Assistance personnel indicated the average time to receive a component through SNAP, from initiation through receipt, averages 12 months. (Interview with Captain Gilles Vernier, 1998) (Phone Interview with Mr. Jack Hyer, 1999) In summary, the SNAP program is certainly applicable to the Canadian Army. Depending upon which alternative source of repair parts for the M109 is selected, there is a likely need for some non-standard support from the United States in the future.

III. NATO MAINTENANCE AND SUPPLY AGENCY (NAMSA)

A. INTRODUCTION

The principal installations of the NATO Maintenance and Supply Agency (NAMSA) and the majority of its 975 personnel are in Capellen, in the Grand Duchy of Luxembourg. (Information Pamphlet, NATO Maintenance and Supply Agency, 1998) NAMSA is the executive body of the NATO Organization of Maintenance and Provisioning (NAMSO) which was created by Council Decision of the North Atlantic Treaty Organization (NATO) in 1958. (Information Pamphlet, NATO Maintenance and Supply Agency, 1998) The NAMSA was formulated to service all of the countries in NATO. Its policies are determined by the NAMSO Board of Directors who serve as representatives of the 15 member nations of NATO. Its mission is "to provide logistic services in peacetime as well as in wartime for weapon and equipment systems held in common by NATO nations, to promote material readiness, to improve logistics efficiency and to effect substantial savings." (Information Pamphlet, NATO Maintenance and Supply Agency, 1998) To carry out this mission, NAMSA has assumed a vast array of responsibilities including maintenance, calibration, supply, procurement, transportation, technical support, and engineering services for over 30 weapon and equipment systems. Additionally, NAMSA provides cooperative logistic services such as codification/ identification, including an electronic mailbox and an electronic data interface (EDI) system that handles more than 500,000 transactions per month. (Information Pamphlet, NATO Maintenance and Supply Agency, 1998) Figure 1 depicts the NAMSA organization with the program management cell responsible for the M109 shaded in gray.



Source: NAMSA Brochure.

Figure 1. The NAMSA Organization Structure

To depict the expanse and capabilities of NAMSA, Table 3 illustrates the participating countries and the weapon systems supported:

Table 3. Weapon Systems Supported by NAMSA

	BE	CA	DA	FR	GE	GR	IT	LU	NL	NO	PO	SP	TU	UK	US
AIRCRAFT															
AWACS	X	X	X		X	X	X	X	X	X	X		X		X
C-130	X	X				X			X	X		X		X	X
MISSLES/ROCKETS															
AMRAAM	X		X		X	X	X		X	X		X	X	X	
HAWK			X	X	X	X	X		X						
MLRS			X	X	X	X	X		X	X			X	X	X
NIKE						X	X						X		
PATRIOT					X				X						X
SIDEWINDER	X		X			X			X	X	X	X	X		
STINGER					X	X			X				X		
TOW		X	X		X	X	X	X	X	X	X		X	X	
ARMY/ARTILLERY															
AMMUNITION		X	X	X	X	X	X		X	X		X	X	X	X
FH-70					X		X		X					X	
M-109 (INCLUDES AUSTRIA)	X		X			X			X	X					
M-110						X						X	X		
M-113	X				X	X			X	X		X	X		
M-60						X					X	X	X		
COMMUNICATION															
SATCOM,CROSS-FOX	X	X	X		X	X	X	X	X	X	X		X	X	X
TARE, IVSN, IDNS, MERCS,	X	X	X		X	X	X	X	X	X	X		X	X	X
SHIP SHORE SHIP BUFFER			X	X	X	X	X		X	X			X	X	
RADAR AND SURVEILLANCE															
DRONE CL-289				X	X										
AIR COMMAND AND CONTROL SYSTEM	X	X	X	X	X	X	XX	X	X	X	X	X	X	X	X

Table 3 (Continued)

	BE	CA	DA	FR	GE	GR	IT	LU	NL	NO	PO	SP	TU	UK	US
RADARS: AN/FPS-117, RAT 31, MPR, HADR, S723, S743 AND OTHERS	X		X	X	X	X	X		X	X			X	X	
RADARS SOUTHERN REGION AND PORTUGAL						X	X				X		X		

Source: NAMSA Brochure.

Legend: BE = Belgium; CA = ; DA = Denmark; FR = France; GE = Germany; GR = Greece; IT = Italy; LU = Luxembourg; NL = Netherlands; NO = Norway; PO= Portugal; SP = Spain; TU = Turkey; UK = United Kingdom; and US = United States.

In addition to the above mentioned weapon systems, the NAMSA also performs an extensive amount of work in logistics. Focusing specifically on the M109, NAMSA has recently established an organization designed to support the logistical needs of the NAMSA members with M109 howitzers. This organization, known as the M109 Weapon System Partnership Committee (WSPC), is the primary tool used by NAMSA in the management of the M109. For purposes of this thesis, the M109 WSPC will be the primary focus for future discussions and analysis.

B. WEAPON SYSTEM PARTNERSHIP COMMITTEE (WSPC)

In November 1996, the WSPC for the M109 was formed. (NAMSO Board of Directors Agreement Number 188, 1996) It currently has five member nations. At this time, Canada and four other nations attend the WSPC conferences as observers. The United States is also one of these observers. The Table 4 identifies these nations, their current M109 configuration, and additional comments regarding the future of their respective M109 fleets. The information contained in this Table demonstrates the extensive use of the M109 throughout the world. NAMSA has recognized this, and with

the United States eliminating support for the M109 in the near future, they have deemed it imperative to establish a concerted logistics effort to support the M109.

The goals of the WSPC focus on three specific areas. The first of these is the procurement, storage, and shipping of spares for the partner nations. (Information Pamphlet, NATO Maintenance and Supply Agency, 1998) With numerous nations possessing the M109, the NAMSA and WSPC can serve as a central agency for the logistics activities of the partner nations. In essence, the WSPC will serve as the support activity for the partner nations.

A second goal is to provide a forum for the partner and observer nations to learn valuable information on the M109. (Information Pamphlet, NATO Maintenance and Supply Agency, 1998) With a multinational membership, the WSPC facilitates sharing of technical information on the technological advances of the various M109s. Additionally, it is a forum for resolving M109 specific problems.

Lastly, the WSPC has a goal of establishing one configuration for the M109. (NAMSA Presentation, 1998, p. 1) Recognizing the difficulty of this, the NAMSA has initiated research on determining what differences actually exist between the member nations. Research indicates the member nations are skeptical about the ability to achieve one configuration for the M109. (Visit Report for WSPC Conference, 1997, p. 3) However, the logistics advantages of doing so are evident. Further discussion/analysis on the advantages and disadvantages of NAMSA/WSPC is located in Chapter V, Analysis of Alternatives.

Table 4. The Partner Nations and Their M109 Fleets

Status	Nation	M109 Configuration	Comments
Partner	Denmark	76 – M109A2	Plan to maintain fleet for indefinite future in existing configuration. May purchase 20-24 PzH 2000 in support of International Bde (European Corps) commitment.
Partner	Greece	135 – M109A1	Looking to upgrade fleet to the M109A5 in the near future.
Partner	Netherlands	126 – M109A2/90 (very similar to the M109A4+ Canadian)	Plan to maintain fleet in existing configuration until 2004, at which time a replacement or major upgrade is scheduled.
Partner	Norway	126 – M109A2	Plan on major upgrade in the near future. Decision on the extent of upgrade will be made this year.
Special Status	Austria	55 – M109A5 & 100 – M109A3	Recently purchased M109A5 from US. Intend to complete upgrade of remaining M109A3 (recently purchased from UK) to M109A5 by the end of this year.
Observer	Belgium	126 – M109A2	Waiting Governmental approval to join the WSPC. Plan to Upgrade their fleet sometime after 2000.
Observer	Canada	76 – M109A4/A4+	Replacement or major upgrade timeframe in question. Was planned for 2005/2006.
Observer	Germany	520 – M109A5 (unique variant)	Plans to remain as observer with M109 usage planned until 2015
Observer	Switzerland	415 – M109A1B, 165 – M109A5 (unique variant)	Plans to remain as observer. Waiting government approval on upgrade of 288 M109s. M109A5 unique variant with Swiss ordnance and other Swiss systems.
Observer	United States	800+ - M109A6	Plans to remain as observer within WSPC. Serve as key link in much of logistic issues due to technical data security.

Source: DASPM 3.

C. NAMSA/WSPC M109 LOGISTICS SUPPORT

Focusing first on repair parts support, the NAMSA's primary objective is to maintain stocks and provide support for a ***standardized*** M109 configuration. In this respect, the emphasis is on identifying those components and repair parts with commonality across the majority of the WSPC members' fleets. Given this fact, the items relevant to a specific Nation's fleet are that Nation's responsibility to maintain. Additionally, each nation shall continue to maintain levels of components/repair parts to sustain their fleets and offset maintenance and supply lead-times. The goal of NAMSA is to serve as the replenishment activity or wholesale supply activity. To facilitate understanding of the magnitude and complexity of the repair parts in question, the following Table illustrates the repair parts unique to the M109A1-A4 models. As a result of the United States eliminating support for these models, the repair parts/components contained in the Table are the focus of the NAMSA. The information in Table 5 will be utilized in future analysis and comparison of alternatives.

Table 5. Critical Repair Parts for the M109A1-A4

NSN	NAME	QTY OH
012360228	Retainer	8
011334048	Plate, ID	0
012732037	Mount, Gun	1
011377539	Cradle, Assy	1
010796115	Plate, ID	166
006723854	Packing, Assy	25
000711967	Pin	346
009836660	Screw	31
009837447	Screw	419
008115032	Screw	179
008114918	Screw	0
009847341	Screw	70

NSN	NAME	QTY OH
0034580052	Follower	11
008016728	Key, Assy	8
004463662	Key, Mach	4
000205617	Shield	2
000205618	Gasket	13
000205620	Retainer	32
001982733	Plunger	0
002551497	Clip	14
001860031	Plate, ID	43
001747758	Plunger	4
004313442	Ball, Check	617
002339051	Tube, Cannon	16

Table 5 (Continued)

NSN	NAME	QTY OH
005501130	Washer	246
005957237	Washer	620
001949213	Washer	728
002748707	Washer	15
006559370	Washer	148
004841843	Tee, Pipe	4
010791090	Bearing	0
008016717	Washer	50
008022459	Nut	21

NSN	NAME	QTY OH
006784283	Holder	64
006739234	Cup, Hammer	20
006780517	Pin	137
006780518	Clevis	14
006780519	Sear	9
006780520	Spring	173
006780524	Pin	6
006739235	Cup, Hammer	3

Source: DASPM 3-2.

The listing of repair parts above is that portion of the listing developed by NAMSA that applies solely to the turret portion of the M109A1-A4 models. NAMSA's configuration listing includes M109A1-A5 models due to some members possessing the A5 model. For the purposes of this thesis, the repair parts above are required for the Canadian Army's future support of the M109.

It is important to identify the costs associated with utilizing the NAMSA. Essentially, they are similar to the costs required for managing repair parts in any system, and they are separated into four areas. These are initial investment, common expenses, administrative costs and individual expenses. (Visit Report for WSPC Conference, 1997, p. 4) The initial investment, as the term implies, corresponds to the establishment of central stock for the partner nation. Essentially, the initial investment provides the NAMSA with the funding required to purchase the necessary repair parts and establish the support accounts for the member nation. It is calculated based upon the partner nation's M109 fleet size, and the number of demands over the most recent two years.

From this information, a quantity required in the NAMSA stock is established. This quantity times the cost equals the initial investment required.

The second cost area is common expenses. In this area, NAMSA is recouping their costs incurred for configuration and engineering work conducted on the member nations' behalf. (Visit Report for WSPC Conference, 1997, p. 4) It is a recurring cost that will be shared between the partners of the WSPC. (Visit Report for WSPC Conference, 1997, p. 4) As of the writing of this thesis, the cost sharing formula had not yet been established. However, research indicated the common expenses are dispersed equally between the partner nations. (NAMSA Presentation, 1998, p. 1) Historical amounts of these expenses is located in Chapter V.

Administrative costs are the third area. These costs are similar to the overhead expenses used in accounting. Essentially, they are the recurring costs associated with the infrastructure of NAMSA, including the salaries of management personnel. The method of allocating the costs to the partner nations is through a simple calculation. NAMSA utilizes the size of the partners' fleets as the allocating base and then disburses the administrative costs accordingly. (Electronic Mail from Mr. Jobe, 1999)

The final cost area to consider is individual expenses. The individual in this case is the partner nation. The costs are entirely within the control of the partner nation, as they apply directly to the supply and maintenance activity of the nation. In other words, these are the costs incurred as repair parts and maintenance actions are purchased. All other costs mentioned in the previous paragraphs are in addition to the individual expenses discussed in this paragraph. (Electronic Mail from Mr. Jobe, 1999)

D. APPLICATION OF NAMSA TO THE CANADIAN ARMY

In an effort to promote thorough understanding of NAMSA/WSPC and its applicability to the Canadian Army, this section outlines and provides a general discussion of NAMSA/WSPC. More specific discussion and analysis are located in Chapter V.

Research indicated the Canadian Army is seriously considering joining the NAMSA/M109 WSPC. Close examination of the Canadian Army situation demonstrates an organization such as NAMSA could be a viable option as an alternate source of supply for M109 repair parts. Support for this statement is seen in the areas of support provided by NAMSA/WSPC. The applicable areas are maintenance, supply, procurement, technical support, and engineering services. An additional area mentioned previously is configuration standardization and configuration management.

The first of these areas to consider is supply support. Supply support is the topic of this thesis and a very important topic with the Canadian Army on the M109. As seen in the preceding Table, NAMSA/WSPC has the capability to provide supply support for many components on the M109. Examining the components and configuration of the Canadian M109 demonstrates that NAMSA/WSPC could easily support their needs.

A benefit of the NAMSA/WSPC providing supply support for the Canadian Army is the possibility of a standardized configuration. In this area the Canadian Army has experienced many problems. (Personal Interview with Major John Weaver, 1998) As previously stated, they have recently initiated a program to standardize the numerous configurations of their two M109 models. The impact of not solidifying or poorly managing the configuration of a weapon system is cataclysmic. During the lifecycle of

the M109, the Canadian Army has had difficulty providing the correct components to the field units. This is a direct result of poor configuration management. This is just one example that demonstrates the significance of actively managing the configuration of a fleet of equipment. Configuration management is only discussed here to demonstrate the applicability of NAMSA/WSPC to the Canadian Army situation, and the specifics of the configuration management issue will be addressed in the next chapter.

The remainder of the services provided by the NAMSA are simply added benefits. Using the technical support as an example, reductions in United States Army personnel and focus towards later models of the M109 will require the Canadian Army to solicit technical support from other sources. The same analogy can be used in each of these other areas of the NAMSA support. The added benefit of one military in a group of other, larger armies is economy of scale. With low usage and minimal numbers of systems, it is a clear advantage for the Canadian Army to utilize the buying power of the NAMSA organization. A comprehensive discussion of this and other key areas will follow in Chapter V.

IV. THE M109 AND THE CANADIAN ARMY

A. INTRODUCTION

As discussed in Chapter I, the need for the M109 in the Canadian Army has been the subject of much debate. With the size of the Ministry of National Defense decreasing and the Cold War ending, much of the questioning has formed on the specific mission of the Canadian Army. Initial research indicated that there was considerable support for a lighter, more agile military. (Personal Interview with Major John Weaver, 1998) Much of this support was within the upper layers of management within the Department of National Defense (DND). However, further research revealed there is continued support for a heavy force structure, which necessitates the need for the M109 fleet. (Interview with Captain Gilles Vernier, 1998) (Phone Interview with Mr. Jack Hyer, 1999) Additional evidence of this support is seen in the support provided for the Leopard tank fleet. For the purposes of this thesis and the decision on a source of repair parts for the Canadian Army, the issue of the expected lifecycle for the M109 is critical. Therefore, emphasis will be placed upon it in Chapter V. The following section will demonstrate there is a future for the M109 in the Canadian Forces.

B. POLITICAL SITUATION AND BACKGROUND

In the recent past, 1995-1997, the Canadian Army has experienced turmoil not uncommon to that of the United States Army. Shrinking budgets and lack of a focus for the force has left many questions throughout the country. The genesis of much of the turmoil and questioning was the Defense White Paper. (Personal Interview with Major John Weaver, 1998) This document is similar to the United States' National Military

Strategy in that it provides the DND with its overall mission and focus. Summarizing the Defense White Paper, it states that the Canadian Forces must maintain the capability to fight on a "high intensity" battlefield. (Personal Interview with Major John Weaver, 1998) More importantly, this battlefield is shared by other nations. This is an important fact and it is readily acknowledged by the Canadian Forces that they will not be in a high intensity conflict as a single entity. (Personal Interview with Major John Weaver, 1998) With numerous nations fighting on the same battlefield, standardization is needed. One key element of standardization is within the divisions and the artillery support they include. In this case, the Canadian Army division cannot be restricted by the indirect fire capability of its artillery. Without the M109 this would be the case.

The topics of the high intensity battlefield, fighting beside other nations, and artillery tactics can involve much discussion and debate. In the case of this thesis however, they are presented solely to support the need for the M109. It is important to also note that the Directorate of Artillery Systems Program Management (DASPM) personnel's interpretation of the Defense White Paper supports the previous discussion. (Personal Interview, Major John Weaver, 1998)

From a political view, further support for the M109 is evidenced in the recent enhancements and rebuilds. Prior to discussing these however, additional background is provided.

Research into the history of the M109 identified three separate upgrades/rebuilds. The first of these was performed to upgrade the original 50 M109s to the M109A1 version with the latest barrel. This upgrade, performed in 1977, was completed in an attempt to ensure the fleet possessed capabilities commensurate with those of other

NATO nations. A second upgrade was performed on these same 50 vehicles in 1982-1983. This involved the upgrade of various components and a rebuild of the complete system. The end result was the Canadian Army possessed 50 M109A3 howitzers in 1983. (Equipment Logistics Directive (ELD) L-04-010-102/LM-001, 1997) (Interview with Captain Gilles Vernier, 1998)

The second purchase of M109A2 models in 1984 enabled the Canadian Army to possess the current United States variant of the M109. However, the United States would soon upgrade its version to the M109A4, leaving the foreign nations with the antiquated M109A2 model. (Equipment Logistics Directive (ELD) L-04-010-102/LM-001, 1997) (Interview with Captain Gilles Vernier, 1998)

A final rebuild was performed starting in 1993 and ending in 1996. During this operation, the Canadian Army established a contract with a European firm in Holland to upgrade and rebuild 30 out of the 76 in the fleet of M109A2/A3s. (Facsimile from Directorate of Artillery Systems Program Management 3-2, 1997) (Personal Interview with Major John Weaver, 1998) Additionally, the remainder of the fleet (46) entered into a similar program at the Canadian Army Depot, 202 Workshop Depot, in Montreal, Quebec. (Facsimile from Directorate of Artillery Systems Program Management 3-2, 1997) (Personal Interview with Major John Weaver, 1998) The complete operation was termed a depot level inspection and repair program (DLIR) by the Canadian Army. The 30 vehicles contracted to the Dutch firm underwent an inspection to identify deficiencies, correction of the deficiencies, and addition of specified modifications. (Personal Interview with Major John Weaver, 1998) The work completed on the 46 vehicles at 202 Workshop Depot was essentially the same as the 30 in Holland minus the specified

modifications. It is this DLIR and the following programs where the discussion on political support focuses.

Subsequent to the 1993-1996 DLIR, the DASPM has initiated numerous upgrade and enhancement programs to the M109 fleet. (Personal Interview with Major John Weaver, 1998) In each of these, support was provided by the Directorate of Land Requirements (DLR). This fact is important, since DLR is the users' representative in all aspects of the weapon system and in this case, the M109. A more important aspect of the Canadian Force structure is that the user, DLR, controls the funding for programs. In order to receive funding from the Ministry of National Defense, DLR must obtain approval throughout the DND chain of command, the personnel directly responsible for the future of the M109. Therefore, DASPM acting on behalf of DLR, had full support in the performance of each of the programs in Table 6.

Table 6. Canadian Army M109 Modifications

Modification	Estimated Cost	Date
Grenade Launchers	$600,000	1993 – 1996
Fire Suppression System	$3,000,000	1993 – 1996
Higher Output Engine	$350,000	1993 – present
Winterization Kit	$1,900,000	1986 – 1996
New Heater System	$780,000	1986 – 1996
Tactical Command Control Communication System (TCCCS)	Cost is Unknown, but will Exceed $3,000,000 for the M109 Fleet	1998 – present
Configuration Management Project	$750,000	1997 – present
Transmission Upgrade	$50,000	1991

Source: DASPM 3-2, 17 November 1998.

In summary the modifications and products identified above and the DLIR, combined with their timeliness, are further demonstration of the overall support for the

continued use of the M109. Economical analysis would disregard these costs as "sunk costs". However, it is in the opinion of the researcher that they demonstrate recent and significant support for the continued use of the M109 fleet. Subsequent to its use, there is the need for logistical support.

C. EXPECTED LIFECYCLE AND USAGE OF THE M109 FLEET

With documentation and evidence to justify the continued support for the M109 fleet, an equally as important topic is the question of the M109's expected lifecycle in the Canadian Army. This question is closely related to the previous discussion on political support. Knowing the political support is present provides superficial evidence the M109 will have a long life in the Canadian Forces. However, there are additional elements that influence a weapon system's lifecycle, not to mention the threat as a significant, if not paramount one. This discussion will be limited to availability of modernization funding and operations and maintenance costs.

The modernization funding in the Canadian Army is minimal. In fact, the entire Ministry of National Defense's budget is approximately $7.5 billion. This is the entire budget for the Air Force, Army and Navy. (Personal Interview with Major John Weaver, 1998) The Army's portion is approximately $3 billion. (Personal Interview with Major John Weaver, 1998) The size of the Canadian Forces in total is approximately 40,000 personnel, necessitating a small amount of the budget for personnel funding. However, when considering the funding required for Operations and Maintenance and personnel, there is little remaining for modernization funding. This fact has impacted the future of the Artillery in the Canadian Forces.

The second key consideration for the Canadian Army is that of operations and maintenance costs. Table 7 outlines key operations and maintenance costs that impact the M109's lifecycle:

Table 7. Operations and Maintenance Cost Categories

Cost Categories	Description
Personnel Costs	Comprised of military personnel costs (MPC) and civilian personnel costs (CPC). Determined by the following factors: quantity; rank or classification; mix of personnel; and location of personnel. Focuses on the personnel required to operate and support the equipment.
Equipment Operating Costs	Comprised of the costs required to operate and support a given piece of equipment. Encompasses fixed, variable and non-recurring costs associated with the equipment. Two key components are Petroleum, Oil and Lubricants (POL) and Spares, Repair, and Overhaul (SR&O).
Facility Operating Costs	Defined as the buildings, works and land required to accommodate personnel and the equipment used by the personnel in the performance of their assigned tasks.

Source: Canadian Finance and Corporate Services Costing Handbook.

Considering the information contained in the preceding table, equipment operation costs are the one variable cost element that significantly impact the operations and maintenance costs of the M109. With the emphasis on ***variable***, as the usage rate of the M109 fleet increases or decreases, so does the associated equipment operating costs. Therefore, the magnitude of these can be controlled by the Canadian Forces through limiting the M109's operation time. And with a per-kilometer operating cost of $317.59, the impact on the lifecycle costs is significant. Applying this to the expected lifecycle of the M109, the decision to limit the operation time allows the Canadian Army management personnel to extend the M109's operational lifecycle. As of this writing, the expected replacement date for the M109 has been extended from 2006 to 2010. These

dates are only estimates, as a final decision will be made in 2003. (Personal Interview with Major John Weaver, 1998)

A detailed history of the M109 usage rates is indicated in Table 8. Fiscal years 93-95 were intentionally omitted, as the usage rates during this time period were minimal due to the DLIR. (Personal Interview with Major John Weaver, 1998) Additionally, it is important to note that the authorized usage did not vary throughout the time period specified. Senior management personnel simply limited the usage through other methods such as rotations to Bosnia and other peacekeeping operations. These did not require the use of the M109.

Table 8. M109 Historical Usage Rates

Year (FY)	Actual Kilometers Per M109/Per year	Authorized Kilometers Per CFR /Per Year
98	180	1200
97	329	1200
96	460	1200
92	935	1200
91	979	1200
90	1151	1200
89	1064	1200

Source: DASPM 3-2.

D. CANADIAN ARMY SUPPLY SYSTEM

1. General

The supply system is a critical component in the analysis of alternative sources of supply. The capability of existing facilities, personnel and documentation all warrant analysis when such decisions are necessary. Additionally, any extraneous situations impacting the supply system should also be considered. In the case of the Canadian Army, the supply system has gone through considerable change in the recent past.

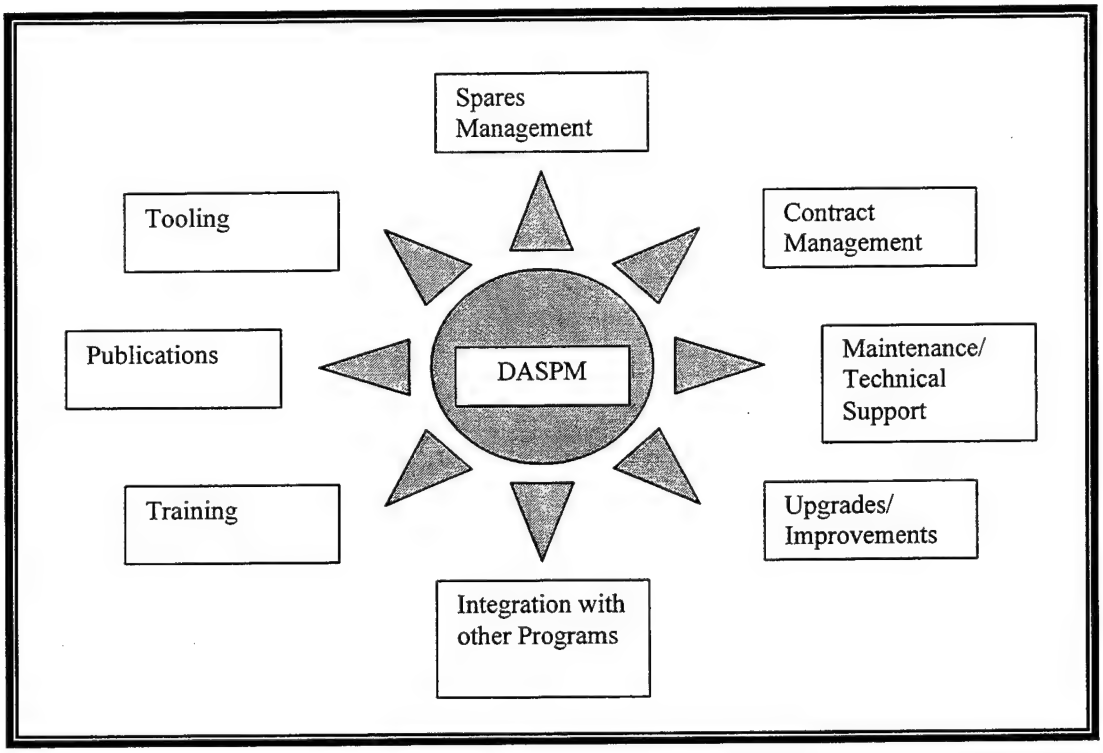
(Interview with Captain Gilles Vernier, 1998) Specifically, there has been a reduction in the number of depots from four to two. And the National Defense Headquarters has also seen considerable changes. With a total restructuring, they have seen the number of personnel in the program management cell decrease. (Personal Interview with Major John Weaver, 1998) The following section will discuss the impact of this on the supply system.

The methods for requisitioning repair parts and the storage are very similar to the United States' system. Requisitions are placed for the items at the organizational level via an automated supply system. Personnel at the local supply organization determine if the item is available in the local stocks. If it is not, the requisition is passed to the installation who performs a review also. If the item is not stocked at the installation, the requisition is then passed to the depot. (Interview with Captain Gilles Vernier, 1998) The depots are essentially identical to any supply warehouse. There are currently two supply depots for the DND. One is located at Canadian Forces Base (CFB) Montreal, and the other is located at CFB Edmonton. (Interview with Captain Gilles Vernier, 1998) Other small supply locations are located throughout Canada, but these are the only two supply depots.

When a repair part is not stocked at a depot, the equipment manager interjects. In some cases, just the item manager for the supply portion can resolve the shortage. (Interview with Captain Gilles Vernier, 1998) However, on most occasions, the involvement of program management personnel is critical to ensuring the correct procedure to resolve the problem is utilized. (Interview with Captain Gilles Vernier, 1998)

2. Role of Program Management Personnel

The program management personnel in the Canadian Army have the most important role in the lifecycle management of a weapon system/equipment. Figure 2 synopsizes this role:



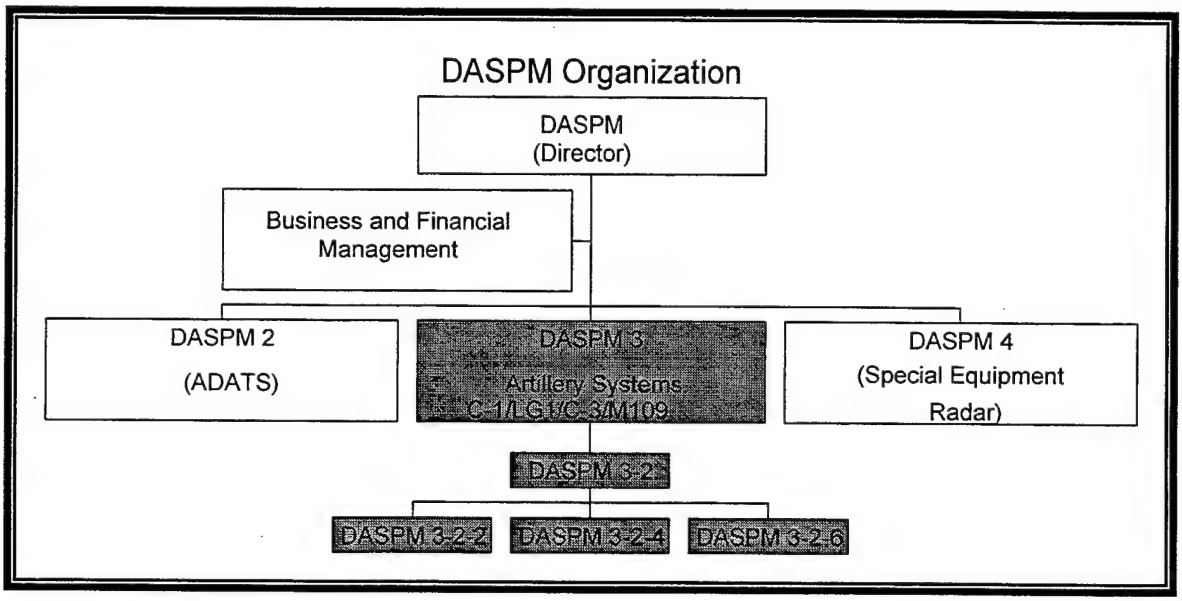
Source: DASPM 3-2.

Figure 2. Management Personnel Role

The purpose of Figure 2 is to demonstrate that any action associated with the equipment must be analyzed and assessed by the program management personnel. The program management office for a weapon system in the Canadian Army stays with the system from its inception through its disposal. (Personal Interview with Major John Weaver, 1998) The skills and numbers of personnel will change after all systems are

fielded, but the core management functions remain with this management cell throughout the lifecycle. (Personal Interview with Major John Weaver, 1998)

In the Directorate Artillery Systems Program Management (DASPM), there are numerous sections responsible for various types of equipment. Figure 3 is an organizational diagram that illustrates the Directorate with the section responsible for the M109 shaded in gray.



Source: DASPM 3.

Figure 3. DASPM Organizational Diagram

There is a total of 15 personnel in the DASPM 3 (Artillery Section). (Personal Interview with Major John Weaver, 1998) As indicated previously, these personnel are responsible for all actions related to the artillery within the Canadian Army. Looking even more specifically at the M109, there are only nine (9) personnel providing management oversight and orchestrating its lifecycle support. (Personal Interview with Major John Weaver, 1998) Recognizing the impact of an understaffed section, the

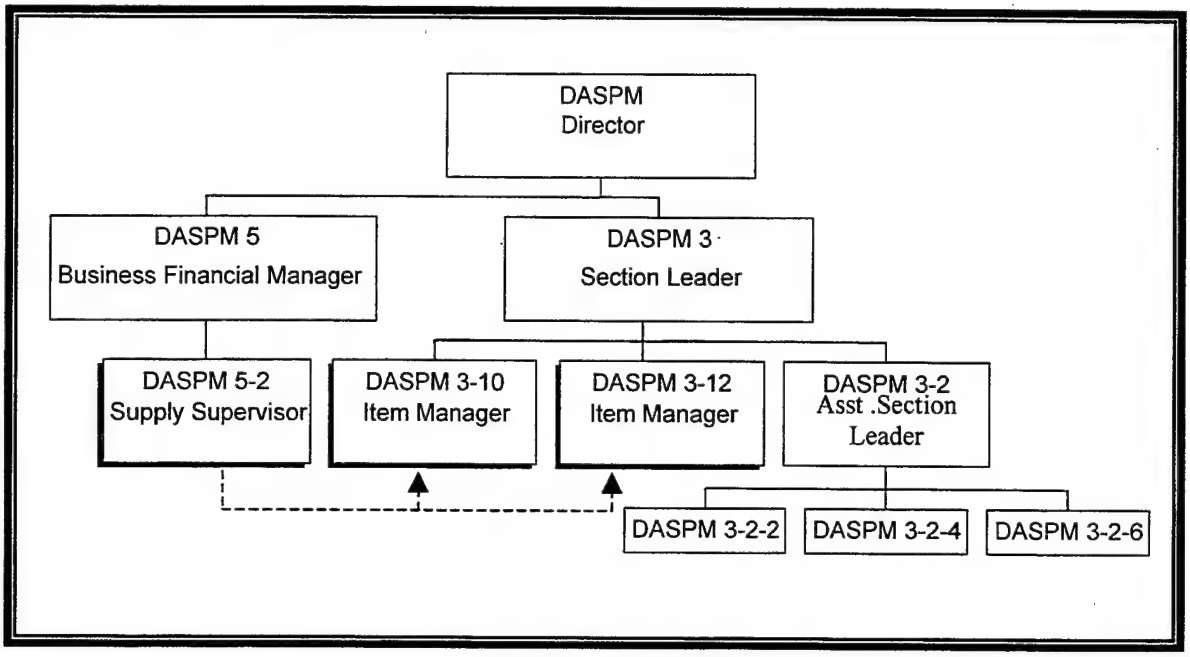
DASPM directed a study be conducted to justify existing positions and personnel in 1994. (Personal Interview with Major John Weaver, 1998) The study focused specifically on the artillery section of DASPM (DASPM 3). The results indicated the section could accomplish approximately 75 percent of its assigned tasks. (Personal Interview with Major John Weaver, 1998) The study analyzed the number of available person-hours of the section versus the person-hours necessary to complete all required tasks. (Personal Interview, Major John Weaver, 1998) Given the ramifications of choosing an alternative source of supply on the workload of a management cell, this information is presented to demonstrate the limited number of personnel in DASPM 3 and their capacity to complete assigned tasks. The impact on the personnel is a significant consideration when applied to the results and subsequent recommendation of this research paper. Further discussion and analysis will follow in Chapter V.

3. Supply System Capacity, Capabilities and Costs

a. Capacity

The purpose of this section is to briefly discuss the structure of the supply system, its capabilities and depict the associated administrative costs related to repair parts management. At the highest level of management in the supply system, the Canadian Army utilizes item managers to provide oversight for a system's associated repair parts. In the case of the M109, these personnel are members of the directorate and directly associated with the section responsible for the weapon system. Recalling Figure 3, which depicts the DASPM organization, the item managers report directly to the section leader Major Weaver. (Personal Interview with Major John Weaver, 1998)

However, Figure 4 depicts the item managers' relationship with the section and the supply supervisors.



Source: DASPM 3.

Figure 4. DASPM 3 Organization (Item Manager Relationship)

As evidenced in this organization chart (Figure 4), the number of item mangers supporting the M109 are limited. There are a total of two item managers for the complete M109 weapon system, with an additional supervisor to provide assistance when necessary. (Personal Interview with Major John Weaver, 1998) It is estimated these personnel manage a total of 14,000 repair parts for the M109 system. (Interview with Captain Gilles Vernier, 1998) The scope of their management is limited to the monitoring of stockages in the depots and requisitioning replacements when necessary. Encompassed in these two overarching responsibilities is a myriad of sub-tasks. Research did not indicate a specific study or analysis was conducted to determine if the number of personnel performing the item manager function is adequate for the tasks

assigned. However, it was stated and acknowledged by the Canadian personnel, that based upon experience and recent downsizing, the item managers are operating at maximum capacity. (Personal Interview with Major John Weaver, 1998) (Interview with Captain Gilles Vernier, 1998) Supporting evidence for this is the reorganization of the supply activity for the Department of National Defense. As a result of this activity, the item managers were assigned to specified directorates, and on two subsequent occasions, reductions in the number of personnel authorized were conducted. (Personal Interview with Major John Weaver, 1998) (Interview with Captain Gilles Vernier, 1998) During each of these reductions, justification was presented to support the current strengths of personnel (item managers), assuming no increases in requirements. (Interview with Captain Gilles Vernier, 1998) As in the management personnel, the importance of the impact on the supply personnel is also critical to the decision on an alternative source of supply for the M109 repair parts. In-depth analysis and discussion will be conducted in Chapter V.

b. Capabilities

Closely related to the supply system capacity is the capabilities and structure of the Public Works and Government Services Canada (PWGSC). This organization provides all of the contracting support for the Canadian government, including DND. (Interview with Captain Gilles Vernier, 1998) It is an expansive organization that is seldom used by the M109 section (DASPM-3). (Personal Interview with Major John Weaver, 1998) However, on the occasion support is needed from PWGSC, there is a long period of time required to establish a contract. Research indicated that a competitive contract requires between six and 12 months to establish

(Interview with Captain Gilles Vernier, 1998) This includes the time from solicitation to contract award. (Interview with Captain Gilles Vernier, 1998) It is commonly understood that the PWGSC personnel are understaffed, which translates to the long time period for contract award. (Interview with Captain Gilles Vernier, 1998)

c. Cost Factors

When considering the alternative sources of supply for M109 repair parts and the preceding areas, it is also important to consider the costs associated with performing some of these administrative and management functions. The Canadian Army has developed a Cost Factors Manual. It is utilized to provide some method for including the costs of administering Department of National Defense (DND) actions, including provision of repair parts, when calculating program/project costs. In this research paper, these costs will be used for cost comparison purposes when performing the analysis of alternatives in Chapter V. The information in Table 9 has been extracted from the Cost Factors Manual, and it depicts the percentages of the total costs of materiel that apply to the respective administrative areas.

Table 9. Recovery Rates for DND Administration

Cost Recovery Areas	% of Total Costs	Notes
Contract Administration	2%	
Temporary Duty and Travel Expenses of Personnel	4%	
Local Procurement by Local Purchase Order (LPO) or Petty Cash	4%	
Commercial Transportation of Materiel	4%	
Provision of Materiel from Inventory	10%	Note
Construction Engineering (CE) – Minor Construction and Maintenance Services Provided by DND CE Resources	10%	Note
Secondment of Personnel to:		

Table 9 (Continued)

Cost Recovery Areas	% of Total Costs	Notes
Other Government Organization	0%	
Non-Government Organization	10%	
All Other Charges	10%	

Note: In addition, the Public Works Government Services Canada (PWGSC) Revenue Dependency Charge, Calculated at 4% of the value of materiel provided, should be added.

Source: Cost Factors Manual 1997-98, p. 7-4.

In addition to the above costs, there are costs associated with the storage of repair parts in depots and warehouses in the Canadian Army Supply System. Again, these are critical to analyzing the alternatives and selecting the optimum solution. Table 10 details these costs.

Table 10. DND Storage Costs

Location	Cost (per cubic meter)
7 Canadian Forces Supply Depot, Edmonton	$43.00
25 Canadian Forces Supply Depot, Montreal	$42.00
Base Storage Location	
Canadian Forces Base (CFB) Edmonton	$654.00
CFB Wainwright	$385.00
CFB Shilo	$325.00
CFB Petawawa	$112.00
CFB Kingston	$279.00
CFB Montreal	$307.00
CFB Valcartier	$255.00
CFB Gagetown	$133.00

Source: Director Supply 2-3-2.

In summary, the costs identified and discussed in Section 3 are those directly associated with the supply support activity in the Canadian Department of

National Defense (DND). Given this fact, they will also play a significant role in the analysis of alternatives in Chapter V.

4. Current Stockages of Critical M109 Repair Parts and Usage

Table 11 depicts the most critical repair parts for the Canadian Army M109. These items are those which differ from the those on the M109A5/A6 and will not be stocked by the United States Army in the future. They are the same repair parts as listed previously in Table 5. However, Table 11 includes the usage of these items over the past 18 months. The repair parts usage information demonstrates the number of demands for each respective part within the Canadian Army. These demands will be used later in Chapter V for the analysis of alternatives, to demonstrate the number of repair parts needed to support the fleet of M109s throughout its lifecycle.

Table 11. Critical Repair Parts for the M109 With Usage

NSN	NAME	QTY OH	18 Month Usage
012360228	Retainer	8	5
011334048	Plate, ID	0	7
012732037	Mount, Gun	1	0
011377539	Cradle, Assy	1	0
010796115	Plate, ID	166	0
006723854	Packing, Assy	25	2
000711967	Pin	346	4
009836660	Screw	31	4
009837447	Screw	419	108
008115032	Screw	179	72
008114918	Screw	0	157
009847341	Screw	70	16
005501130	Washer	246	60
005957237	Washer	620	50
001949213	Washer	728	77
002748707	Washer	15	2
006559370	Washer	148	15

Table 11 (Continued)

NSN	NAME	QTY OH	18 Month Usage
004841843	Tee, Pipe	4	4
010791090	Bearing	0	1
008016717	Washer	50	3
008022459	Nut	21	5
003458052	Follower	11	11
008016728	Key, Assy	8	5
004463662	Key, Mach	4	1
000205617	Shield	2	1
000205618	Gasket	13	8
000205620	Retainer	32	7
001982733	Plunger	0	5
002551497	Clip	14	9
001860031	Plate, ID	43	6
001747758	Plunger	4	2
004313442	Ball, Check	617	119
002339051	Tube, Cannon	16	2
006784283	Holder	64	6
006739234	Cup, Hammer	20	5
006780517	Pin	137	15
006780518	Clevis	14	3
006780519	Sear	9	6
006780520	Spring	173	5
006780524	Pin	6	9
006739235	Cup, Hammer	3	2
006803821	Spring	22	12
006780530	Lever	15	8
008635637	Plunger	4	1
008619992	Spacer	8	8
008609169	Pin, Firing	45	30
008611473	Pin, Locking	453	40
008959182	Firing Mechanism	75	2
009559454	Brake, Muzzle	12	0
009254165	Handle, Breech	7	0
000340896	Hammer	17	2
000657548	Spring	40	4
007574787	Carrier	0	2

Source: DASPM 3-2.

V. ANALYSIS OF ALTERNATIVE SOURCES OF SUPPLY

A. OVERVIEW

This chapter will analyze and compare two alternative sources of supply. The advantages and disadvantages of the alternatives will be compared with respect to several measures of evaluation. On the basis of these measures, a recommendation will be made as to what is the best course of action for the Canadian Army to take to maintain a satisfactory supply support system.

The first source of supply alternative is the NATO Maintenance and Supply Agency (NAMSA). As addressed in Chapter III, this organization is relatively new and essentially provides the Canadian Army with its only other viable source of supply. It will be referenced as the NAMSA alternative or alternative one for the remainder of the thesis. The second alternative centers on the Canadian Army continuing to use their existing stocks and augmenting these utilizing the Simplified Non-standard Acquisition Program (SNAP), Foreign Military Sales (FMS), or Direct Commercial Sales. Here after, this alternative will be addressed as the augmentation alternative or alternative two.

B. ALTERNATIVES

1. The NATO Maintenance and Supply Agency (NAMSA) – Alternative One

This alternative simply requires the Canadian Army to join the NAMSA organization as a means of supply support. The NAMSA is capable of providing the repair parts and support necessary to maintain the Canadian Army's fleet of M109's.

2. Augmentation – Alternative Two

The augmentation alternative, as the name implies, focuses on augmenting the existing stockages of repair parts, if need be in the future. The Canadian Army will

continue to use their on-hand quantities of repair parts and in the event there are additional quantities needed, three other means of ***augmenting*** these stocks can be used. They are Direct Commercial Sales (DCS), Foreign Military Sales (FMS), and the Simplified Nonstandard Acquisition Program (SNAP). These are termed augmentation methods and are not sufficient by themselves to be included as independent alternatives for complete support of the Canadian M109 fleet. Further discussions of each follow in Section 3.

4. Augmentation Methods

a. Direct Commercial Sales (DCS)

Research revealed that the applicability of DCS to the Canadian Army situation is extremely limited. The underlying reason for this centers on the proprietary nature of the M109 Technical Data. It was found that the technical data for the critical components listed in Table 11 is strictly regulated by proprietary laws. (Personal Interview with Master Warrant Officer Raoul Proteau, 1998) Essentially, the Canadian Army is required to contract with the original equipment manufacture (OEM), now United Defense. Due to the low usage and age of the equipment, a significant number of items are no longer produced or supported by the OEM. (Phone Interview with Mr. Jack Hyer, 1999) It is important to recognize that the OEM could produce the items, but considering the measures of effectiveness (MOE) of overall cost, timelines, and technical support and configuration management, this alternative does not warrant further consideration or analysis. However, DCS is an alternative to obtaining repair parts and components on a limited basis or to augment the primary means of support.

b. Simplified Nonstandard Acquisition Program (SNAP)

Another augmentation method is the SNAP. It was discussed in detail in Chapter II. The utilization of the SNAP is intended to focus on those repair parts needs that cannot be obtained through other acquisition methods. As discussed in Chapter II, it is used for components and repair parts no longer supported in the United States Army system. In applying it to the Canadian Army case, SNAP could be used for the critical components listed in Table 11. However, the time required to receive the part makes it an inefficient method for all repair parts needs. Like the DCS, the SNAP is a viable method to augment the primary means of support.

c. Foreign Military Sales (FMS)

Given that no System Support Buy-out (SSBO) will be offered by the United States Army and the critical components will continue to be supported until stocks are exhausted, Foreign Military Sales (FMS) is also an augmentation method. A detailed discussion on FMS was included in Chapter II. Focusing on the critical repair parts in Table 5, it is nearly impossible to determine how long these will be supported in the United States Army system. Additionally, the NAMSA has stated it intends to purchase significant quantities of the remaining repair parts in the United States Army system. (Electronic Mail from Mr. Jobe, 1999) Both of these add significant uncertainty to the viability of using FMS as a source of supply. However, as addressed with DCS and SNAP, FMS is a potential option for augmenting the primary source of supply.

C. MEASURES OF EVALUATION

Before performing the analysis of these alternatives, it is important to identify and discuss the evaluation measures used. For the purposes of this paper, these are termed

decision-making measures of effectiveness (MOE) and are utilized to aid in determining the optimum source of supply for the Canadian Army. The researcher has included the MOEs that cover the complete spectrum of information relevant to the decision required. It is important to note that no MOE is weighted or determined to be more important than the others. Discussions with Canadian Army personnel support this action. (Personal Interview with Master Warrant Officer Raoul Proteau, 1998)

In summary, the MOEs will be utilized for discussion, analysis and ultimately in comparison of the alternatives. During the comparison of the alternatives, detailed information will be provided on the measurements of each MOE.

1. Cost Measures of Effectiveness

The most significant of the MOEs used is cost. There are a myriad of costs associated with acquiring repair parts and support for a fleet of equipment and more specifically, the Canadian M109. Figure 5 depicts the cost measures of effectiveness that will be used. As noted, the NATO Maintenance and Supply Agency (NAMSA) alternative includes three costs within the cost MOEs: 1) administrative costs; 2) Common Expenses and 3) Initial Investment. In general, the alternatives will be assessed and analyzed on the basis of their respective cost MOEs. As depicted in Figure 5, the administrative costs associated with the NATO Maintenance and Supply Agency (NAMSA) include materiel management costs, holding costs and procurement costs for the augmentation alternative.

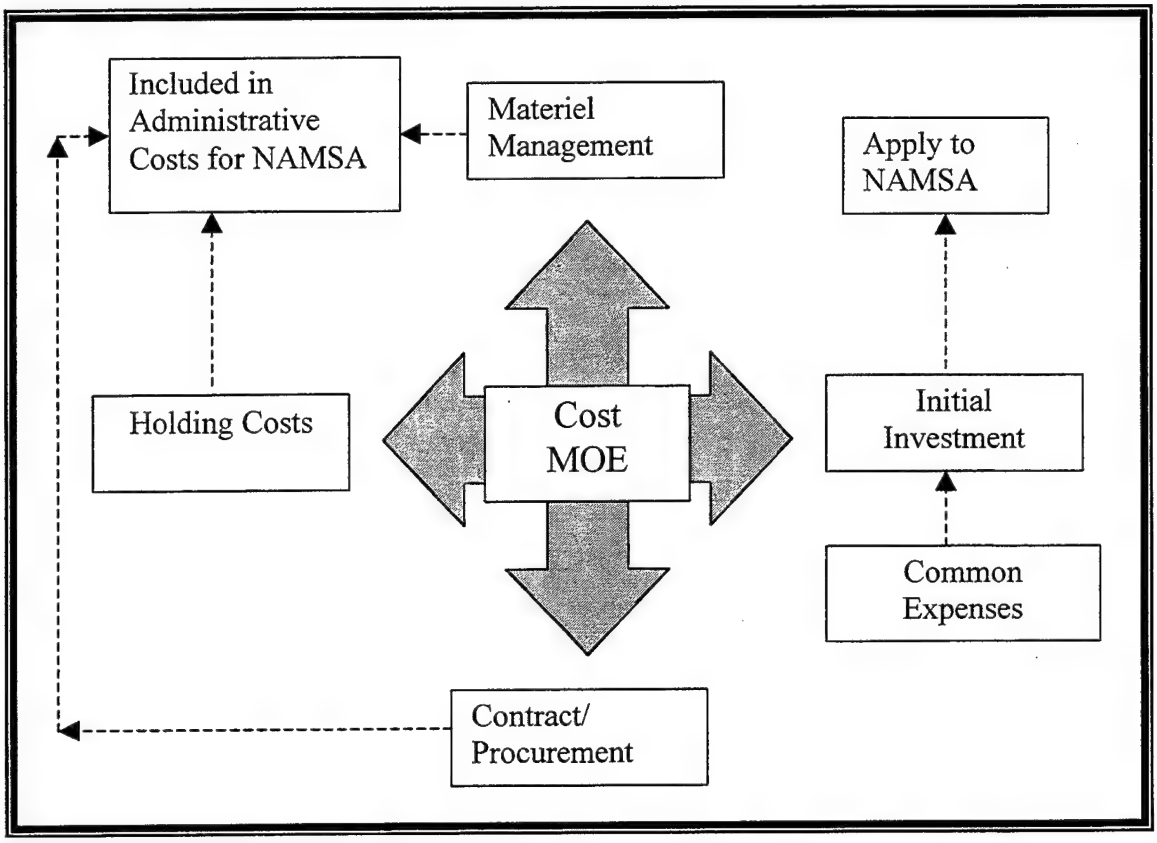


Figure 5. Description of Costs

a. Materiel Management Costs

The Materiel Management costs include those that are incurred requisite to the management of the repair parts and components for the M109. For analysis purposes, these include the costs of management personnel in the program office, the supply item managers and the depot management required for the repair parts. In a previous discussion, these costs were listed in Table 9 as "provision of materiel from inventory" costs. The more significant the management costs are the less attractive the alternative is.

b. Holding Costs

For the purposes of this research, the holding costs are restricted to the costs of holding repair parts and components in the Canadian Army Depots. Holding costs are estimated as a cost per cubic meter of space occupied by the repair parts.

c. Procurement/Contract Costs

Procurement/contract costs are those directly associated with the purchase of repair parts/contract costs. The costs of contracting for the Canadian Army are identified as a percent of the overall cost of the repair parts.

d. Administrative Costs

The administrative costs for the NATO Maintenance and Supply Agency (NAMSA) are those required for the infrastructure and support for the M109 Weapon System Partnership Committee (WSPC). This MOE applies to the NAMSA alternative, as there is no corresponding cost for alternative two. Figure 5 depicted the relationship between the two.

e. Common Expenses

Members in the NAMSA incur a cost identified as common expenses. For this thesis, it only applies to the NAMSA alternative. Research revealed it covers the expenses of engineering and configuration work performed by the NAMSA on behalf of the members. (Electronic Mail from Mr. Jobe, 1999) The cost sharing formula is critical to this MOE, as it is simply shared equally between the partner nations. The benefit derived from these expenses is uncertain at this time. Provided this fact, the NAMSA common expenses will be added to the costs incurred with the NAMSA alternative. Further discussion will take place in the comparative analysis, Chapter V, Section E.

f. Initial Investment

The final cost MOE is the initial investment. Again, it is applicable to the NAMSA alternative and is a measure of the dollar value of the initial investment required. This expense is critical to the analysis given its significance and the time value of money.

2. Other Measures of Effectiveness (MOE)

Other MOEs that will be utilized in the analysis of alternatives are: 1) Political Support; 2) Integration of the Expected Lifecycle; 3) Support Timeliness; 4) Technical Assistance and Configuration Management; and 5) Quality. Table 12 provides a general description of each MOE.

Table 12. Description of the Measures of Effectiveness (MOE)

Measure of Effectiveness	Description
Political Impact	Considers the alternative's acceptability with current political issues.
Integration of the Expected Lifecycle	Compares the expected lifecycle of the M109 in the Canadian to the alternative and determines if it is cost beneficial.
Timeliness of Support	Considers the timeliness of supply support of each alternative.
Technical Assistance and Configuration Management	Evaluates the capability of the alternative to provide these to the Canadian Army
Quality	Focuses on the quality of the repair parts and service being provided by the alternative source.

a. Political Impact

Political impact is often overlooked in many decision-making analyses. Therefore, this MOE focuses on the acceptability of the alternative, given the current political issues. In this area, analysis will be provided on the conformance of each alternative to the political environment in Canada. The analysis will be based upon the

information obtained from Canadian Army sources, thus making it subjective in nature. There is no objective, quantifiable value placed on this MOE.

b. Integration of the Expected Lifecycle

A critical area is the expected life of the M109 in the Canadian Army. Although the alternatives do not readily impact the expected life of the M109, there is a requirement to consider the degree to which the alternative is cost beneficial when compared to the planned disposal date of the M109 fleet. This MOE facilitates consideration of the impact the remaining lifecycle of the M109 has on the quantity of repair parts needed.

c. Support Timeliness

One measure of the success of supply management is the timeliness of the system. The system in this context is the procedures and physical activity required to order and receive a part/component. This is a critical MOE when considering alternate sources of supply, and is even more critical in the Canadian Army given the large quantity of repair parts received from foreign sources. The geographical locations of suppliers and potential suppliers impact timeliness. Each alternative will be evaluated using the timeliness MOE based upon the number of days required to receive a repair part.

d. Technical Assistance and Configuration Management

In considering the size and capabilities of the Canadian Army support staff, technical assistance and configuration management are two critical tasks that the Canadian Army requires assistance with. Currently, a significant portion of these is provided by the United States Army. However, when support is eliminated for the

M109A1-A4 models by the United States Army, these tasks will also be reduced. Given this, the Canadian Army will need to consider other alternatives for obtaining this support. It is understood that technical assistance and configuration management are key ingredients to and inseparable from a support relationship. Therefore they are an important consideration in determining an alternate source of supply. For this thesis, they are considered as an MOE for determining the optimum solution, and each alternative will be analyzed on its ability to provide or facilitate these two services.

e. Quality

The final MOE utilized for this analysis is quality. The term quality in this respect stipulates the quality of parts and services. To the extent possible, the researcher will attempt to document the quality provided by each alternative. However, it is important to note the information utilized in the analysis will be subjective and based upon interviews with personnel representing varying organizations.

D. ANALYSIS OF ALTERNATIVES

The assessment of the alternative sources of supply for the Canadian Army's M109 support will be conducted through the analysis of each alternative utilizing the measures of effectiveness identified in Chapter V, Section C. The two alternatives will be assessed based on the definitions and discussions of the MOEs. Subsequent to this assessment, a comparative analysis will be conducted to determine the optimum solution in Chapter V, Section E.

1. The NAMSA – Alternative One

Alternative one, as defined above and previously discussed, is one of particular interest to the Directorate of Artillery Systems Program Management (DASPM).

(Personal Interview with Major John Weaver, 1998) As stated, DASPM is responsible for the lifecycle support of the Canadian Army M109 fleet.

a. Cost Measures of Effectiveness (MOE)

The costs of alternative one are the first MOEs to consider and analyze. Alternative one requires costs associated with an initial investment, common expenses and administrative costs. Figure 5 depicted these costs

(1) **Initial Investment Costs.** Looking first at the initial investment, these are the costs incurred by the partner nation as a result of the NAMSA purchasing their initial inventory of repair parts. These stocks will then be drawn on by the partner nation. The NAMSA will replace them with the funding provided by the partner nation as the repair parts are requested. In this situation, the partner nation is Canada. The initial investment is calculated based upon the partner nation's M109 fleet size, and the number of demands over the most recent two years. From this information, a quantity required in the NAMSA stock is established. This quantity multiplied times the cost of each NATO Stock Number (NSN) equals the initial investment required. (Electronic Mail from Mr. Jobe, 1999) The initial investment is estimated at $900K for the Canadian Army. (Visit Report for WSPC Conference, 1997, p. 4) At this time, it is only an estimate due to the lack of demand data which are not yet available. (Personal Interview with Major John Weaver, 1998) The NAMSA has stated that repair parts may be provided as credit for a portion or all of the initial investment. (Visit Report for WSPC Conference, 1998, p. 3) This fact provides an opportunity for the Canadian Army to clear their depots of excess repair parts, which in-turn provides a minimal savings in

holding costs. It is unknown how many repair parts the Canadian Army could provide at this time for a payment-in-kind. (Personal Interview with Major John Weaver, 1998)

The significance of the initial investment is seen in the time value of money. To recoup any of the initial investment costs, the Canadian Army will need to achieve some savings through the NAMSA organization. Depending upon the amount of savings, if any, a number of years will be required to offset the initial investment costs. This fact will also impact on the Integration of Expected Lifecycle MOE. In summary, the initial investment costs associated with alternative one are significant.

(2) **Administrative Costs.** Administrative costs are included in the second MOE for alternative one. For 1998, the administrative costs for each partner nation (shared equally between all) totaled approximately $82k per year. (Electronic Mail from Mr. Jobe, 1999) Using the previous figure of $538,896 for annual repair parts purchases and assuming the administrative cost will remain constant if the Canadian Army were to join, the administrative costs equate to 15.2 percent of the purchases. Note that these costs are incurred regardless of the quantity of repair parts purchased.

Given the relative newness of the NAMSA, there is little historical data to facilitate an accurate estimate of the financial impact on the administrative costs if the Canadian Army joins. It is understood the costs will be shared between seven nations instead of six. However, there will be additional infrastructure costs associated with another member. The NAMSA M109 Program Manager indicated that $82K is an accurate value for the administrative costs. (Electronic Mail from Mr. Jobe, 1999)

(3) **Common Expenses.** A final cost MOE, Common Expenses, includes required engineering and configuration management costs to be reimbursed by the partner nations. For 1998, the total common expenditures for the NAMSA, M109 WSPC were $401,675, and each nation's share was $80,335. (Electronic Mail from Mr. Jobe, 1999) However, the 1999 estimate is significantly less at $34,966. (Electronic Mail from Mr. Jobe, 1999) Using the 1999 estimate as the value for the MOE, it equates to 6.5 percent of the estimated annual purchases ($538,896).

(4) **Political Impact.** The characteristics of alternative one adversely impact its assessment using this measure of effectiveness. The climate in Canada surrounding the military is turbulent, and has been documented previously. Two areas that impact the climate will be addressed.

The first of these areas is the high initial investment costs. It is estimated, using the NAMSA formula, these costs will exceed $900K. This is a significant cost when compared to the DASPM's budget and even the Canadian Army's budget, which is estimated at $1.125B. (Personal Interview with Master Warrant Officer Raoul Proteau, 1998) The Canadian people are critical of expenses, especially when the dollars are spent in another country.

Another area of concern is its acceptance by senior leadership of the Department of National Defense (DND). As previously cited, there is concern and uncertainty over the mission of the Canadian Army. Given this, there is a hesitancy on the part of senior leadership to accept large expenditures. Furthering this issue is the nature of the expense. With its focus being on *support/maintenance*, there is a tendency

to overlook or discount its importance. (Personal Interview with Major John Weaver, 1998)

(5) **Integration of Expected Lifecycle.** Considering the expected lifecycle when making a support decision is essential and in the case of this MOE, cost is the primary concern. As a degrading characteristic of alternative one, its costs require financial analysis in comparison to the expected length of time that the M109 fleet will be in the Canadian Army. The basis for this statement centers on the high initial investment required to establish the support inventory of repair parts. With the Canadian Army likely to receive some credit from the NATO Maintenance and Supply Agency (NAMSA) for repair parts provided to them, the specific cost of the initial investment is unknown. However, research indicated the Canadian Army will incur some cost. (Personal Interview with Major John Weaver, 1998) As previously stated, if no credit (payment-in-kind) is received, the Canadian Army's initial investment would be approximately $900K.

Considering the time value of money and assuming a seven percent discount rate, it would require a savings of $113,311 per year to recover the initial investment costs. Table 13 demonstrates various scenarios for initial investment quantities and the annual savings required over a 12-year period to recoup the initial investment. Twelve years ends in 2011, one year beyond the estimated replacement date for the M109.

Table 13. PV Calculations for Alternative One Savings

	Annual Savings Required		
Initial Investment	**6% Discount Rate**	**7% Discount Rate**	**8% Discount Rate**
$900k	$107,349	$113,311	$119,425
$800k	$95,421	$100,719	$106,156
$700k	$83,493	$88,129	$92,886
$600k	$71,566	$75,539	$79,617
$500k	$59,638	$62,949	$66,347
$400k	$47,711	$50,359	$53,078
$300k	$35,783	$37,769	$39,808
$200k	$23,855	$25,179	$26,539
$100k	$11,927	$12,589	$13,269

As evidenced in Table 13, regardless of the initial investment, alternative one will have to afford the Canadian Army some savings in the other cost areas to be considered financially sound.

(6) **Timeliness of Support.** With the location of the NATO Maintenance and Supply Agency (NAMSA) in Luxembourg (Europe), there is an indication of increased shipping times. As of the writing of this thesis, there is only an estimated shipping time available, and discussions with the NAMSA program manager for the M109 indicated there is a one day (24hrs) release time for parts in stock. (Electronic Mail from Mr. Jobe, 1999) It is estimated that items ordered through commercial contracts or foreign military sales (FMS) with the United States will take between 90 – 180 days. (Electronic Mail from Mr. Jobe, 1999) It is important to note that the NAMSA obtains a great deal of their M109 repair parts through the United

States' system. This makes shipping an issue for the Canadian Army. It is not efficient to ship a repair part from the United States' supplier to Europe and then back to North America (Canada). The NAMSA M109 Project Manager acknowledged this and stated that a direct shipment to Canada from the United States is possible. Assuming this is correct and with no foreseeable problems with the NAMSA internal supply system, their timeliness of support is significantly impacted by the United States.

(7) **Technical Assistance and Configuration Management.** The capability of the source of supply to provide the technical assistance and configuration management is again, a key MOE. With the United States Army eliminating support for the M109, there will be degraded support in the two areas of this MOE. Alternative one has unique characteristics in both of these areas.

The first is having the ability to access and learn from six partner nations with varying versions of the M109. Every country provides unique insight on the M109 to the other partners of the Weapon System Partnership Committee (WSPC) of the NAMSA. It is from this insight and sharing that one form of technical assistance is provided.

The NAMSA also has a more formal technical assistance capability. Research indicated they have experienced engineers capable of resolving specific repair parts issues. (Electronic Mail from Mr. Jobe, 1999) In the event a partner nation has technical problems or questions, the NAMSA will work to resolve them.

In the area of configuration management, alternative one has performed initial work on establishing a number of configurations for the partner nations. (Electronic Mail from Mr. Jobe, 1999) It encompasses establishing a baseline

configuration for each partner nation's M109. This project is in its early stages of development and much work is still required. (Electronic Mail from Mr. Jobe, 1999) However, it does demonstrate the potential capability to provide configuration management.

(8) **Quality.** Due to the short period of time the NAMSA WSPC has been operating, it will be difficult to assess its ability to provide quality repair parts and services. One aspect of the NAMSA where quality is an issue is in the receipt of parts from the partners for payment-in-kind. There is concern that some of the repair parts in the NAMSA stocks are unserviceable. It is certainly a concern with the Canadian Army and other partner nations. (Visit Report for WSPC Conference, 1998, p. 3) Offsetting this however, is information that demonstrates adequate quality control for the NAMSA. Research revealed that quality control within NAMSA inspects the incoming repair parts, including payment-in-kind parts. In the event the part is unserviceable, they will reject it. (NAMSA Presentation, 1998) Table 14 provides a summary of quantities of repair parts provided by the partner nations versus the number accepted by the NAMSA. (NAMSA Presentation, 1998)

Table 14. Quality Control Samples

Country	Line Items/Value Shipped	Value Accepted by NAMSA
Norway	486/$720,691	$65,072
Netherlands	847/$944,772	$419,217

Table 14 provides some evidence of quality assurance being performed by the NAMSA. Further justification is seen in the information provided by

the NAMSA warehousing manager. (Visit Report for WSPC Conference, 1998, p. 4) Their method for mitigating the risk of receiving unserviceable parts is as follows:

1. A 100 percent in-inspection of all parts received is carried out. Any visibly non-serviceable (N/S) parts are not accepted, and returned to the sender at their cost;

2. All parts are re-packaged if not up to NATO standard; and

3. All items with a unit value of over $200 are labeled indicating their source, i.e., procured through foreign military sales (FMS), procured from industry, or provided as a contribution in kind by a member nation. Repeated discrepancies are dealt with quickly by the NAMSA through this method.

Source: DASPM 3.

Due to the lack of information and evidence on the quality of repair parts provided to customers, assessment of alternative one in the quality or repair parts is based upon the preceding information.

A second area within the quality MOE is service. Again, however, there are insignificant data to enable thorough assessment of alternative one. Information provided by Canadian Army personnel and United States Army personnel, who have worked with the NAMSA management, indicate there are no discrepancies with their service

2. Augmentation - Alternative Two

a. Cost Measures of Effectiveness (MOE)

The analysis of alternative two will follow in the same format as alternative two. As discussed in the preceding paragraphs and depicted in Figure 5, there are three cost MOEs applicable to the augmentation alternative. In an effort to simplify the analysis, these costs are depicted in Table 15.

Table 15. Summary of Alternative Two Costs

Description of Cost	Cost Calculation	Estimated Annual Cost
Holding Costs	$42/43 per cubic meter	$5,762
Materiel Management Costs	10 percent of total cost	$53,889
Procurement Costs	4 percent of total cost	$21,555

(1) **Holding Costs.** Holding costs are directly associated with the storage of the repair parts in Canadian Army Supply Depots. The holding costs accumulated for the repair parts at lower levels are not considered. Justification for not including the lower levels is seen in the requirement to hold small quantities of repair parts at the levels of supply near the operational units. (Interview with Captain Gilles Vernier, 1998) Additionally, for future comparison purposes, the Canadian Army Supply Depots and the NATO Maintenance and Supply Agency (NAMSA) would perform very similar functions. These two agencies incur the holding costs at the same level, and the holding costs for the lower level organizations in the Canadian Army will exist regardless of the source of repair parts.

Another consideration for the holding costs however, is the quantity of repair parts on hand. The Canadian Army depots, as evidenced in Table 5, have considerable quantities of M109 repair parts in their inventories. In comparison to the past usage (Table 11), a significant number of these quantities are excessive. Holding excess repair parts impacts the holding costs. After a cursory look, the quantities in excess appear to have a significant adverse impact on the holding costs. However, a closer examination revealed the sizes of the components, excluding the cannon tube,

cannon mount, and cradle, are insignificant. Given that the holding costs are based upon the size of the component/part, the holding costs are relatively insignificant.

The costs depicted in Table 15 are annual. Therefore parts and components received as replenishments from other sources such as SNAP or DCS are included in these holding cost calculations. The annual holding costs for the critical repair parts as a percentage of the annual procurement are approximately one percent.

(2) **Materiel Management Costs.** The second cost MOE to consider is materiel management costs. Assuming the use of the Cooperative Logistics Supply Support Agreement (CLSSA) includes the annual requirements for M109 repair parts, the materiel management costs could be estimated based upon the previously stated value for CLSSA purchases. This value was $538,896 for the period 1 Jan 97 – 17 Nov 98. And the value, recalling from Table 9, for materiel management costs was 10 percent of the total repair parts costs. Multiplying this value times $538,896 equates to $53,889 in materiel management costs. It is assumed these are accurate and representative of the actual costs incurred. Research, as previously stated revealed the management functions within the Directorate of Artillery System Program Management (DASPM) are understaffed. Understanding this and assuming the cost factor in Table 9 is representative of the actual costs, substantiates the belief that the costs are not inflated or overstated. It is understood that the cost factors are estimates developed by the Department of National Defense (DND). However, they will facilitate a quantifiable comparison to the NAMSA alternative.

(3) **Contract/Procurement Costs.** The contract/procurement costs for alternative two are estimated at $21,555. This number was calculated by

multiplying the DND cost factor of four (4) percent times the annual requirement for M109 repair parts. Again, the annual requirement was calculated by compiling the total Cooperative Logistics Supply Support Agreement (CLSSA) purchases from 1 January 1997 – 17 Nov 1998. This total is the same as stated previously, $538,896. It is important to reiterate that replenishment of stocks and periodic purchases are included in this number.

b. Other Measures of Effectiveness (MOE)

(1) **Political Impact.** As discussed previously, the political impact of the alternative is critical. The specifics of the political situation are addressed in Chapter IV. Discussions with Canadian Army personnel revealed that the general public does not support large military expenditures. (Personal Interview, Major John Weaver, 1998) Justification for this statement is seen in the recent reductions of military personnel over the past five years, and the Air Force is facing another 17 percent over the next year. (Personal Interview with Master Warrant Officer Raoul Proteau, 1998) The defense budgets have also been decreasing. Over the most recent three years, the Department of National Defense has seen a 50 percent reduction in their budget. (Personal Interview with Master Warrant Officer Raoul Proteau, 1998)

In addition to this, the general public is quite vocal. The Canadian Army personnel in the Directorate of Artillery System Program Management (DASPM) stated ministerial inquiries are quite common when the expenditure is questioned. (Equipment Logistics Directive (ELD) L-04-010-102/LM-001, 1997) (Interview with Captain Gilles Vernier, 1998) A ministerial inquiry refers to an incident when some

individual processes a concern (writes some correspondence) to the Ministry of Defense. These are a significant concern to the military personnel, even if they are unsubstantiated.

A second issue for the M109 management personnel is support from the Ministry of Defense and other senior personnel in the Department of Defense (DND). Questions concerning the future mission of the DND were previously addressed. With these questions and the subsequent uncertainty over the structure of the DND, any significant expenditure will have to be fully justified.

Alternative two, with no up-front expenditure, and relatively low risk is compliant with each of these issues/concerns. Additionally, it affords flexibility to the management personnel in the event changes in the political environment take place. In summary, the political situation surrounding the military is tense. However, alternative two's impact on this situation should be small with its focus towards using existing stocks and only purchasing replenishments as necessary.

(2) **Integration of the Expected Lifecycle.** An MOE related to the political impact addresses the expected lifecycle of the M109. As stipulated, the M109's lifecycle in the Canadian Army is uncertain. Research did reveal its date for replacement has been extended from 2006 to approximately 2010. (Personal Interview, Major John Weaver, 1998) Alternative two, given its minimal initial investment, will require no extended time period to recoup any costs.

(3) **Support Timeliness.** An important aspect of any supply support organization is the timeliness of the support provided. It is also a measure of the organization's quality, which will be addressed later. The specific measure of timeliness in this MOE is the time required from the requisition placed by the operational unit to

their receipt of the part. For alternative two, after making a key assumption, its timeliness is adequate. The key assumption is the time required for the part to be manufactured or obtained through the United States will be calculated into the reorder point calculations. Knowing this and the usage of the repair parts, allows the item managers to make the extended time for the Simplified Nonstandard Acquisition Program (SNAP) and Direct Commercial Sales (DCS) invisible to the operational units. When considering that greater than 90 percent of the M109 requisitions are processed through the Cooperative Logistics Supply Support Agreement (CLSSA) and Foreign Military Sales (FMS), it is apparent the M109 item mangers are intimately familiar with accounting for long lead-time parts. Assuming the item managers perform their tasks as required, alternative two will not change the support provided to the operational units. The current estimates for receiving parts from the Canadian Army depots is five-eight days. (Interview with Captain Gilles Vernier, 1998)

(4) **Technical Assistance and Configuration Management.**

To assess the impact of technical assistance and configuration management, commonality of repair parts between the United States and the Canadian Army variants of the M109 is an important issue. Research revealed that there is between 85 and 90 percent commonality between the two models. As previously addressed, there are critically important repair parts in the 10 to 15 percent.

Not having the United States actively engaged in the use and support of these repair parts is a disadvantage for alternative two. The Canadian Army personnel rely upon the expertise of the United States Army engineers responsible for the weapon system. In this case, the M109 program management team for the United States

actively provides assistance to the Canadian Army in the resolution of technical problems. Research indicated greater than 90 percent of this assistance is related to repair parts. (Interview with Captain Gilles Vernier, 1998)

Compounding the issue of future configuration management is the purchase of repair parts through the use of Direct Commercial Sales (DCS) and the Simplified Nonstandard Acquisition Program (SNAP). In each of these there is the likelihood of the Canadian Army receiving a component that is dissimilar than those currently in use. Alternative two will require intense configuration management by the Canadian Army. Given the documented shortage of personnel, this task, even though a small number of parts are impacted, will create added tasks that exacerbate this fact.

A final consideration with this MOE is the large quantity of repair parts on hand. As depicted in Table 11, there are significant quantities of the critical repair parts needed for the M109 Support. These quantities, combined with the low usage rates for the M109 fleet, lessen the impact of this MOE. With large quantities of repair parts, it is likely fewer DCS and SNAP requisitions will be needed and the dependence upon United States Army technical support will be reduced. The quantities of repair parts on-hand depicted in Table 11, combined with their Cooperative Logistics Supply Support Agreement (CLSSA), will provide the Canadian Army with continued support for their M109 fleet for some a period of time.

(5) **Quality.** The final MOE identified is quality. In this situation, the quality of alternative two is based primarily upon the United States Army system. Research, based upon interviews with the Canadian Army personnel, revealed some situations where the quality of repair parts provided by the United States Army was

inadequate. Two examples of these are the fuel tanks for the M109 and transmissions for the M578 recovery vehicle. In the case of the fuel tanks, the specifications were not correct and they simply did not fit into the hull of the M109. (Personal Interview with Master Warrant Officer Raoul Proteau, 1998) The two transmissions on M578s were rebuilt in a United States Army Depot and lasted less than 100kms. (Personal Interview with Master Warrant Officer Raoul Proteau, 1998) Neither of these applies to the M109 turret, however, they demonstrate that quality may be a potential problem with United States' repair parts and a potential disadvantage for alternative two.

Offsetting the preceding, there is also an advantage to working with a large military like the United States and it lessens the impact of poor quality. This advantage is having large quantities of M109s being used and essentially producing data. These data support identifying and resolving any quality issues. Contrasting this statement, smaller organizations with a lower density of equipment such as the Canadian Army may have difficulty in defining the root cause of a quality deficiency.

Other quality considerations center on the use of Direct Commercial Contracting (DCS) and the Simplified Nonstandard Acquisition Program (SNAP). In each of these, the quality of the product and service are dependent upon the manufacturer. The researcher did not conduct analysis on the manufacturers of each repair part, but instead assumed their quality is commensurate with other potential suppliers in the industry. Therefore, quality should not be an issue with either of these forms of acquisition.

E. COMPARISON OF ALTERNATIVES

With analysis completed, this Section will provide comparison and discussion of the alternatives. Ultimately, the result of the comparison will determine the best. A summary of the comparisons will follow the discussions and Table 17 will depict the results of the analysis performed. Further, it provides the overall assessment of the alternatives within each measure of effectiveness.

The definitions of the criteria used for each MOE are based upon a subjective scale. There are three possible ratings within each MOE. An ***adequate*** rating equates to sufficient evidence, qualitative or quantitative, that the alternative conforms to the requirements of the MOE. A ***marginal*** rating symbolizes that there is not sufficient data to warrant determining the alternative either adequate or inadequate. Lastly, an ***inadequate*** rating represents an assessment where there is evidence that identifies the alternative as having significant deficiencies in accordance with the MOE. The methodology to be employed for the comparative analysis is to conduct a comprehensive comparison of the alternatives' assessments as they apply to each MOE.

1. Costs

In Table 17, one cost MOE is presented to simplify the comparison. As discussed in the preceding section however, there are underlying costs within this MOE. Additionally, the two alternatives entail different costs. Therefore, they will be compared as depicted in Figure 6. The three cost categories for alternative two will be compared to the administrative costs for alternative one. For the purposes of the analysis and comparison, the costs for both alternatives in this category will be referred to as

administrative costs. The additional costs associated with alternative one will be addressed separately.

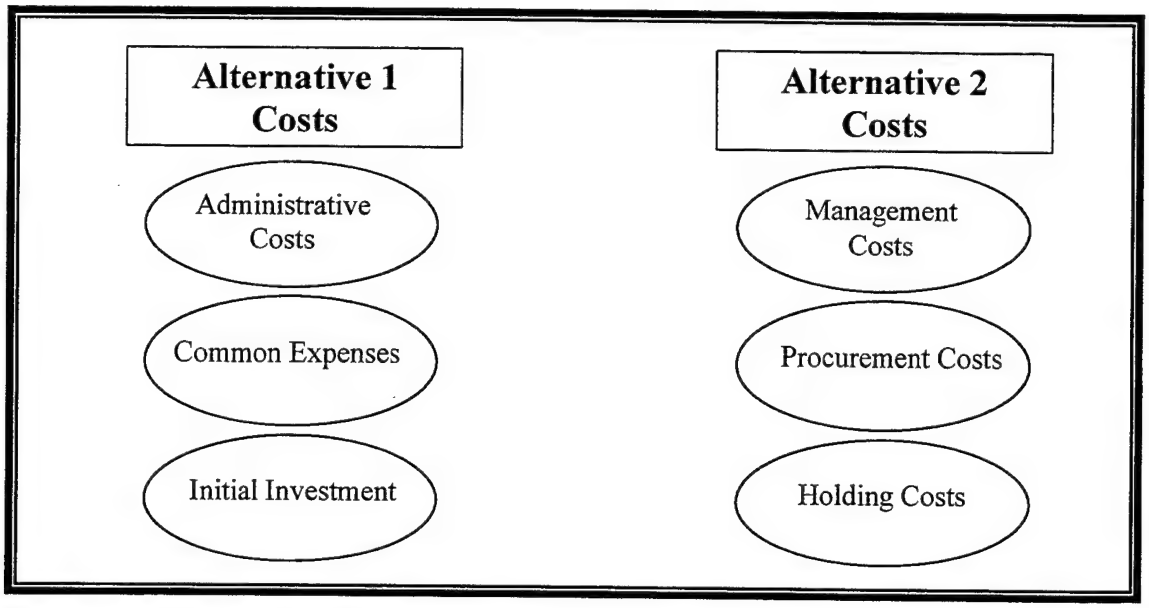


Figure 6. Cost Comparison

The value of the administrative costs has been assessed as a percent of the total annual repair parts procurement costs. Table 16 provides the specific percentages of each.

Table 16. Costs Values Comparison

	Administrative Costs		Other Recurring Costs		Total Costs	
Alternative	**Percent (%)**	**Total Value**	**Percent (%)**	**Total Value**	**Percent (%)**	**Total Value**
One	15.2	$82,000	6.5	$34,966	21.7	$116,966
Two	15.6	$84,207	0	0	15.6	$84,207

As represented in Table 16, the recurring costs for alternative one exceed those for alternative two by 6.1 percent. The caveat to this statement however, is the differential between the two is directly attributable to the common expenses associated

with alternative one. These expenses, as previously noted, cover the costs incurred by the NATO Maintenance and Supply Agency (NAMSA) for the technical assistance and configuration management work accomplished on behalf of the partner nations. With this statement in mind, it is important to consider the benefit derived from these services. The discussion that follows will discuss each service separately.

Technical assistance and its application to the Canadian Army has been documented. In determining its importance, the paramount consideration for this comparison is the number of repair parts impacted. In other words, what parts will the Canadian Army personnel likely need assistance with. The answer to this question is 10 – 15 percent of the repair parts for the complete M109. The approximate quantity is 100. The United States Army, as previously noted, will no longer support these. However, it is a relatively minor number when compared to the nearly 10,000 total repair parts on the M109.

The form of the technical assistance is another factor. The NAMSA offers engineering services for the partner nations. Research indicated the Canadian Army's use of engineering services to correct problems, perform modifications, or perform analysis on the repair parts in question has been minimal in the past five years. (Personal Interview with Master Warrant Officer Raoul Proteau, 1998) Additionally, there is a small probability they will need such services in the future. (Personal Interview with Master Warrant Officer Raoul Proteau, 1998) Further research indicated the most likely modification to the M109 would be an upgrade to a later version of the gun mount used on the M109A5 model. (Personal Interview with Major John Weaver, 1998) In the event the Canadian Army performed the modification, the benefit derived from the NAMSA's

technical assistance subsequent to this would be minimal since the United States Army still supports the M109A5.

A benefit of the technical assistance provided by the NAMSA, is the information sharing between the partner nations. The benefit derived from the information is difficult to estimate. It is simply documented as a benefit to consider.

The configuration management provided by the NAMSA also warrants discussion. In this area, the goal for the NAMSA is to establish a configuration control database. Research revealed a configuration status accounting program was initiated by the NAMSA on 25 July 1997. (NAMSA Memorandum 1997) This program was initiated to provide the partner nations with information regarding the configurations of the assorted M109 variants. The underlying theme is for the database to serve as a focal point and decision support tool when any of the partners is considering modifications or upgrades. This is certainly a viable benefit however, further research suggests that the NAMSA might have difficulty in establishing an ***accurate*** database. (Visit Report for WSPC Conference, 1998) The research conducted centers on the modifications taking place by the partners. Two examples of these are: 1) Norway's use of ordnance similar to another European howitzer, the FH-70; and 2) Germany, which is considering joining the NAMSA, indicated they will modify 263 M109s with a KUKA semi-automatic loader. These are only two examples of countries initiating changes to their equipment. For one country to track all of the changes for its own fleet is a difficult task. Accounting for the changes in six or seven countries' fleets is exponentially more difficult. Based upon all of this and the researcher's experience with the Canadian Army, it is in the opinion of the researcher that the likelihood of the NAMSA establishing an ***accurate***

configuration control database is minimal. Therefore, the benefit derived by the Canadian Army is also minimal.

Relating the preceding discussion to the comparison of costs. As depicted in Table 16, the costs associated with the performance of technical assistance and configuration management totals approximately 6.5 percent. And the difference in the recurring costs is 6.1 percent, with alternative two being less costly. In order for alternative one to be considered financially better based solely upon recurring costs, the benefit derived from these services will have to offset the 6.1 percent. It is acknowledged that some benefit would be received by the Canadian Army for the two services in question, if it were to join the NAMSA. However, based upon the factors discussed, it is not significant enough to offset the additional costs (6.1 percent).

Extending the preceding discussion further, there is another cost consideration. It is that of the initial investment. Table 15 portrayed the required benefit over the 12 year remaining lifecycle of the M109 to offset a given initial investment. Considering the recurring costs of the two alternatives in Table 16, it should be noted that alternative one will not provide any recurring cost savings, but a cost deficit. The initial investment required only exacerbates the cost issue.

In summary, the costs of alternative one are significantly greater than alternative two. In light of this, Alternative one is assessed to be inadequate, while Alternative two is to be adequate.

2. Political Impact

The primary discriminator between the two is the presence of the initial investment for alternative one. As previously described, the military in Canada has fallen

under extreme scrutiny. In turn, it has impacted the decisions made by military leadership and the Minister of National Defense. The fallout of all of this is uncertainty regarding the future of the military, and a resistance to making significant investments with uncertain returns. This is precisely the issue with alternative one. With an initial investment estimated at $900k, there is room for scrutiny from the public and senior military personnel. The political impact of alternative one appears more significant when compared to alternative two, which has no initial investment and low risk. Based upon this, Alternative one is assessed to be marginal and Alternative two is assessed to be adequate for this measure of effectiveness.

3. Integration with the Lifecycle

The concern within the MOE of "Integration with the Lifecycle" is whether the alternative is financially sound or not. The measure used for this is a calculation of the net present value of the alternative using the end of lifecycle date as the end of the money stream. As previously identified and discussed, an initial investment is required for alternative one. Given that the costs can be offset with a payment-in-kind (i.e., repair parts from the Canadian Army Inventory), there is a probability of reducing the out-of-pocket expense. However, there will be some initial investment. As demonstrated in Table 14, there is some annual savings required to financially justify the initial investment. It is unlikely, based upon research, that any annual savings will be realized with alternative one. This adds to the uncertainty and risks associated with alternative one. Contrasting alternative one, alternative two has minimal risks relative to financial viability. In considering the expected date for the end of the M109 lifecycle, alternative two is not constrained by an initial investment and an offsetting benefit period.

Additionally, it is not sensitive to changes in the lifecycle plans for the M109 fleet. In summary, Alternative one is assessed to be marginal and Alternative two is assessed to be adequate.

4. Timeliness

This MOE was based strictly on the order-ship times for the alternatives. They were both very similar in the number of days for shipping times and with both using foreign military sales (FMS), direct commercial sales (DCS), or the simplified nonstandard acquisition program (SNAP) as primary means for repair parts, there is little variability between the two alternatives. Both alternatives were assessed as adequate.

5. Technical Assistance and Configuration Management

This MOE measures the capability of the alternative to provide the technical assistance and configuration management services. Previous discussions regarding this MOE have demonstrated that the Canadian Army, with alternative two, will suffer some loss of benefit in both of these tasks. The loss is a direct result of the degradation in support for the older models of the M109 by the United States Army. With this affecting only 10 – 15 percent of the repair parts on the Canadian M109, the researcher determined the loss is not significant.

It was previously documented that the NATO Maintenance and Supply Agency (NAMSA) provides technical assistance and configuration management services. Although it is acknowledged there are unanswered questions concerning the quality of the configuration management, it is important to stress the significance of the technical assistance benefit. The NAMSA provides this service, both formally and informally through the partner nations and information sharing. The potential benefit in this area

compensates for any marginal benefit from the configuration management program. Alternative one is assessed to be adequate, while Alternative two is assessed to be marginal for this MOE.

6. Quality

Research revealed evidence of the NAMSA and the United States Army providing quality repair parts and services. Even though there are incidents of defective repair parts in the United States Army system, there is evidence and justification that offsets these deficiencies.

A related issue is that both alternatives use FMS, DCS and SNAP as sources for repair parts. In this situation, the quality of the repair parts and services received are dependent upon the same organizations. Therefore, the variance between the two is minimal. The assessments of both alternatives within the quality MOE are adequate.

F. SUMMARY

Table 17 reflects the assessments of the alternatives with respect to each MOE. The overall assessments are based upon a subjective compilation of the individual assessments for the MOEs. Alternative one's overall assessment is marginal. The basis for this reflects its low ratings in the MOEs of cost, political impact and integration with lifecycle. By comparison, Alternative two's overall assessment is adequate. Alternative two received adequate assessments in each MOE except for the technical assistance and configuration management MOE.

It should be noted that the results of the analysis and comparisons are provided without weighting for any of the MOEs. As stated, the Director Artillery Systems and

Table 17. Assessment of Alternatives

	Measures of Effectiveness (MOE)						
Alternatives	**Overall Cost**	**Political Impact**	**Integration with Lifecycle**	**Timeliness**	**Tech Assistance & Config. Mgt.**	**Quality**	**Overall**
One	I	M	M	A	A	A	**M**
Two	A	A	A	A	M	A	**A**

Legend:

A = Adequate
M = Marginal
I = Inadequate

VI. CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

The issue of M109 supply support for the Canadian Army is an important one. Research indicated the Canadian Army was interested in joining the NATO Maintenance and Supply Agency (NAMSA) for a possible alternative source of supply. (Personal Interview with Major John Weaver, 1998) Subsequent to this determination, the information was assessed relative to the decision required, and analyzed with respect to two possible alternative sources of supply. The first alternative is the NAMSA. This alternative simply requires the Canadian Army to join the NAMSA organization as a means of supply support. The NAMSA is capable of providing the repair parts and support necessary to maintain the Canadian Army's fleet of M109s. The second alternative is the Augmentation of existing stocks. This alternative, as the name implies, focuses on augmenting the existing stockages of repair parts, if need be in the future. The Canadian Army will continue to use their on-hand quantities of repair parts and in the event there are additional quantities needed, three other means of ***augmenting*** these stocks can be used. They are Direct Commercial Sales (DCS), Foreign Military Sales (FMS), and the Simplified Nonstandard Acquisition Program (SNAP). These were termed augmentation methods and are not included as independent alternatives for complete support of the Canadian M109 fleet.

Using the data and information gathered, measures of effectiveness were developed to aid in the decision making process. These MOEs were then utilized as the basis for analysis. The MOEs were separated into two general areas, costs and other. The costs were further divided into specific MOEs based upon the specific costs

associated with each alternative. These are represented in Figure 7, while Table 18 depicts the other MOEs utilized. On the basis of these MOEs, a comparative assessment was conducted and a recommendation as to which alternative was preferable was made.

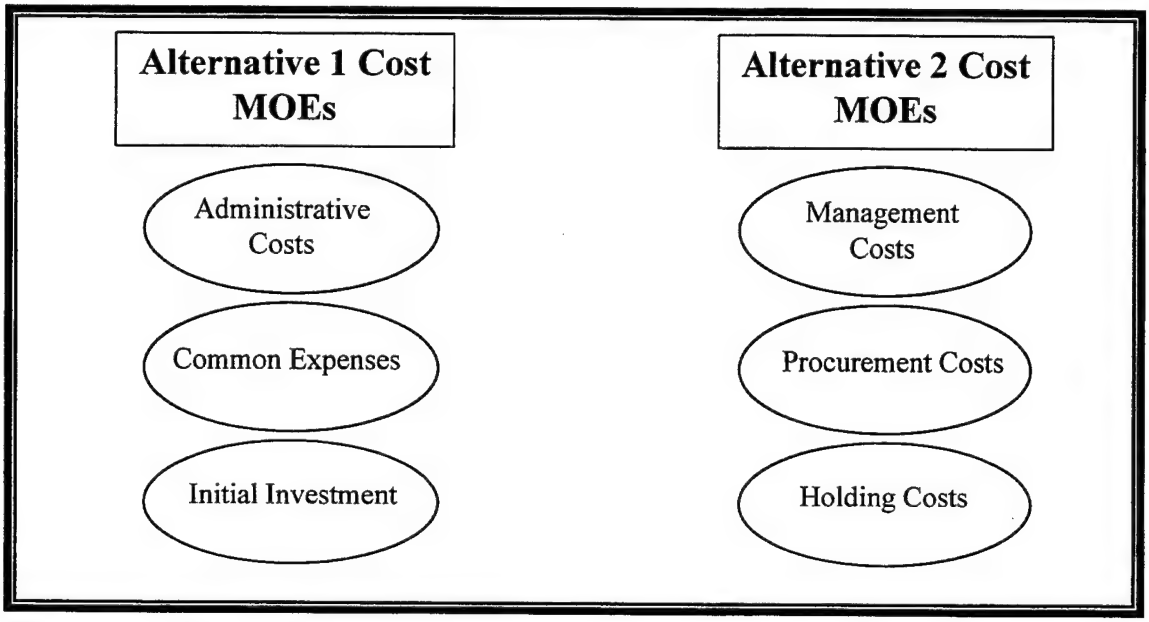


Figure 7. Cost MOEs

Table 18. Other Measures of Effectiveness (MOE)

Measure of Effectiveness	Description
Political Impact	Considers the alternative's acceptability with current political issues.
Integration of the Expected Lifecycle	Compares the expected lifecycle of the M109 in the Canadian to the alternative and determines if it is cost beneficial.
Timeliness of Support	Considers the timeliness of supply support of each alternative.
Technical Assistance and Configuration Management	Evaluates the capability of the alternative to provide these to the Canadian Army
Quality	Focuses on the quality of the repair parts and service being provided by the alternative source.

B. CONCLUSIONS

The results of the analysis indicated that the **augmentation – alternative two** is the better source of supply for the Canadian Army than the **NAMSA – alternative one.** The following is a summary of the advantages and disadvantages of the two alternatives. (See Table 17, p. 85)

1. Advantages and Disadvantages of the Alternatives

a. The NATO Maintenance and Supply Agency (NAMSA) – Alternative One

The NAMSA offers a unique situation where the partner nations are able to share and learn from each other's experiences. The nature of the experiences vary, but most are centered on technical issues related to modifications and repair parts. Given the limited number of M109s and usage in the Canadian Army, the NAMSA could provide the management personnel with valuable data/information. This is an important advantage for alternative one.

Alternative one's numerous costs, however, provided a significant and adverse impact on its overall assessment. Of these costs, the initial investment cost constituted a significant portion of the impact. The adverse effects of the initial investment cost is further exacerbated due to its political impact and the lack of any offsetting, future financial benefit. As a result of these considerations, the costs associated with alternative one are a critical disadvantage.

b. Augmentation – Alternative Two

Alternative two is a low cost solution to the Canadian Army's support issue. It has no up-front investment, which in-turn allows flexibility for the program

management office in the future. The minimal initial cost of alternative two is a significant advantage.

Alternative two adheres to the current political environment in Canada, primarily as a result of the minimal costs. Additionally, it has no inherent issues with quality or timeliness.

By essentially relying on internal support and some augmentation from the United States Army, alternative two forces the Canadian Army to apply more effort towards obtaining technical assistance and resolving configuration management issues. As previously discussed, the manpower of the Directorate of Artillery Systems Program Management (DASPM) is limited. Therefore, the added burden of performing/managing these activities is a disadvantage for alternative two.

Another significant consideration involved with alternative two is the quantities of the critical repair parts on hand in the Canadian Army depots. These combined with the low usage rates for the M109's, provided evidence that the Canadian Army has the capability to continue to support their fleet for some time. However, there is some uncertainty as to the exact quantities on hand and the usage rate of the critical stock numbers.

The augmentation methods are a key component of alternative two. These were previously identified as Direct Commercial Sales (DCS), Simplified Nonstandard Acquisition Program (SNAP) and Foreign Military Sales (FMS). The augmentation method will vary depending upon the characteristics of the repair parts being procured.

The DCS method provides the Canadian Army with the capability to purchase repair parts directly from the manufacturer. It is applicable to all of the critical repair parts for the M109. When compared to the other methods, a key advantage for the

DCS method is timeliness. Offsetting the timeliness however, is the likelihood of increased costs. If the Canadian Army were purchasing an item that had not been produced for some time, the manufacturer will incur added costs for restarting a cold line. This cost will in-turn be passed on to the Canadian Army.

The SNAP method is very similar to DCS and is applicable to all of the critical components/repair parts on the M109. The primary difference is that the SNAP requires the United States Army to purchase repair parts for the customer nation. It initially appears good, but there is an inherent disadvantage with the SNAP. As previously indicated, it is extremely time consuming. Additionally, the same start-up costs associated with DCS can be applied to the SNAP.

The final augmentation method for alternative one is FMS. Foreign Military Sales (FMS) is applicable in those situations where the repair part is still being supported by the United States Army. This is a general rule, as there are no absolutes with FMS. Research indicated the Canadian Army utilized FMS to acquire the services of a United States Army Depot to rebuild components for a system that had been out of service for over five years. (Personal Interview with Master Warrant Officer Raoul Proteau, 1998) It is acknowledged that most of the critical items identified for the M109 are small repair parts, not items for rebuild. Therefore, they are considered candidates for FMS until they are no longer in the inventory. Once they are no longer in the United States Army inventory, another augmentation method will be required. Like the SNAP, FMS is also a timely process and this is a key disadvantage for it. An advantage to FMS is the probability of reduced costs when compared to the other methods. A significant portion of these can be attributed to the economies of scale achieved in the United States Army purchases.

c. Overall Assessments of the Alternatives

The results of the overall alternative assessments for each MOE are presented in Table 19. Alternative one's assessment for the cost MOE was rated as inadequate. It received marginal assessments in the MOEs of political impact and integration with the lifecycle and adequate in the other MOEs. Alternative two received an adequate assessment for each MOE except for the technical assistance and configuration management MOE, which was rated as marginal. Considering the rating within each MOE, alternative one's overall assessment was marginal and alternative two's overall assessment was adequate.

Table 19. Assessment of Alternatives

	Measures of Effectiveness (MOE)						
Alternatives	**Overall Cost**	**Political Impact**	**Integration with Lifecycle**	**Timeliness**	**Tech Assistance & Config. Mgt.**	**Quality**	**Overall**
One	I	M	M	A	A	A	**M**
Two	A	A	A	A	M	A	**A**

Legend:

A = Adequate

M = Marginal

I = Inadequate

It should be noted that the results of the analysis and comparisons are provided without weighting on any of the MOEs. As stated, the Director Artillery Systems Program Management (DASPM) concurs with this action. However, if any of the MOEs significantly outweighed another, the overall assessment could change.

With the recommendation to implement the Augmentation – alternative two, it is necessary to also consider the different augmentation methods. Each method has distinct advantages and disadvantages, which determine its applicability to the needed repair parts. These were used to recommend the augmentation methods. Table 20 depicts the recommended methods, segregated by whether the repair part is being supported by the United States Army or not. If the repair part is supported, the order of preference is FMS, DCS and SNAP. The lower cost of FMS offsets its poorer timeliness when compared to DCS. Both FMS and DCS are rated higher than SNAP in timeliness, and FMS is likely to be less costly than SNAP. If the repair part is no longer supported by the United States Army, the order of preference is DCS with FMS and SNAP being equal. In this situation, DCS has an advantage in timeliness over the other two methods. Foreign Military Sales and SNAP are rated equal in this situation due to the similar costs and long delivery times.

Table 20. Recommended Augmentation Methods

	Order of Preference for each Situation	
Augmentation Method	**Repair Parts Still Supported**	**Repair Parts Not Supported**
Direct Commercial Sales (DCS)	2	1
Foreign Military Sales (FMS)	1	2
Simplified Nonstandard Acquisition Program (SNAP)	3	2

C. RECOMMENDATIONS

The purpose of this thesis was to provide research information and analysis on the issue of what type of supply support system should be used in the future for the M109 fleet in the Canadian Army. Based upon this purpose and the analysis conducted, it is recommended that the Canadian Army initiate the Augmentation - alternative two and not join the NAMSA. In conjunction with this recommendation, the recommended augmentation method if the repair part is still supported is FMS. If the repair part is not supported then DCS is the recommended augmentation method. As a result, the following specific actions are recommended:

1. The DASPM 3 office should initiate detailed inventories to determine the exact stock numbers and quantities on hand. At the same time, the personnel can determine serviceability of the repair parts;

2. Based upon the results of an inventory, DASPM 3 should determine the quantities of the critical repair parts needed to support the fleet for the remainder of the lifecycle. This can be conducted by analyzing the usage rates of the M109s, the repair parts usage and the current on-hand quantities; and;

3. With the results of the analysis, DASPM 3 can requisition any shortage stock numbers through the United States Army.

D. AREAS FOR FURTHER RESEARCH

The following areas are recommended for additional research:

1. An Analysis should be Conducted on the Impact of the Elimination of Support for the M109A1-A4 Fleet on Security Assistance

There are a significant number of nations that possess the M109 howitzer. Additionally, it is likely many of these nations will purchase significant quantities of repair parts through the United States Army Security Assistance Command (USASAC). Provided this, the elimination of support for the M109A1-A4 models potentially impacts

the operating costs, structure and revenue of USASAC. Further research and analysis should be conducted in this area to determine the costs and benefits of the elimination of support for the M109 on the USASAC.

2. The NATO Maintenance and Supply Agency (NAMSA) as a Potential Source of Usage Information for the United States Army Should be Investigated

Provided the on-going problems and design changes with the M109, obtaining usage input from other nations appears to be an advantage. With numerous members, the NAMSA is a potential source for usage information on the M109 for the United States Army. It was noted that the United States Army is an observer for the NAMSA M109 Weapon System Partnership Council (WSPC) meetings (Phone Interview with Mr. Jack Hyer, 1999) However, the precise benefit of the Army's current role is unclear and therefore, a closer analysis is warranted.

APPENDIX A. INTERVIEW WORKSHEET

Chapter and Topic	Who/What/When/Where?
I. Introduction	-Political Situation -Newspapers on Defense Issues -M109 History, dates purchased, rebuilds conducted, costs, expected lifecycle.
II. Security Assistance	-Need modifications to the Chassis portion with parts/components effected -Need overall CLSSA expenditures with specific costs for the M109 fleet -Need to discuss SNAP with COLOG personnel
III. NAMSA	-Obtain all information available from Major Weaver. Need Internet addresses -Cost to join (what is conversion if repair parts are used to pay fee?) -Listing of M109 repair parts currently available through NAMSA? -Commonality of parts (is Canada one of the only countries with the old version M109)?
IV The M109 and the Canadian Army	-History-History-History -What parts are affected? (CF version) -Current political situation -Has mission been determined? -Expected lifecycle -Usage rates for the fleet -Supply system current stockages of M109 repair parts -Supply system capabilities including costs for maintaining A part in storage/stocks? -Costs to contract a part with timeframe? -Number of personnel in office? What is the future number?
V Analysis of Alternatives	- Any cost and management data are useful.
VI Conclusion and Recommendation	-Suggestions for further research?

APPENDIX B. LIST OF ACRONYMS

AECA	Arms Export Control Act
CFB	Canadian Forces Base
CLSSA	Cooperative Logistics Supply Support Agreement
DCS	Direct Commercial Sales
DASPM	Directorate Artillery Systems Program Management
DLR	Director Land Requirements
DLIR	Depot Level Inspection and Repair
DND	Department of National Defense
DoD	Department of Defense
ESF	Economic Support Fund
FAR	Federal Acquisition Regulation
FMS	Foreign Military Sales
FMSO	Foreign Military Sales Order
FMFP	Foreign Military Sales Financing Program
IMET	International Military Education and Training
IPP	Industrial Preparedness Planning
LOA	Letter of Offer and Acceptance
MFO	Multinational Force and Observers
MND	Ministry of National Defense
MOE	Measure(s) of Effectiveness
NAMSA	NATO Maintenance and Supply Agency
NAMSO	NATO Organization of Maintenance and Provisioning
NATO	North Atlantic Treaty Organization
OEM	Original Equipment Manufacturer
PKO	Peacekeeping Operations
SNAP	Simplified Nonstandard Acquisition Program
SSBO	System Support Buy-out
USASAC	United States Army Security Assistance Command
USG	United States Government
WSPC	Weapon System Partnership Committee

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